““# SCHOOL SCIENCE AND MATHEMATICS

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When the War Department asked for pre-induction courses, science and mathematics teachers came through and, within a few weeks' time, were doing the job that had to be done. The importance of science and mathematics in the curriculum is recognized now, but what will happen when the war is over? Administrators are looking to us for guidance in the future planning for our subjects at the various grade levels and for the different ability and interest groups. We must work together to give the necessary guidance.

In general, science and mathematics teachers have not supported their organizations as well as they should. They did not keep up to date on the trends in their field. But this is changing. Local organizations are becoming very active, and larger area and national organizations are showing an increase in membership. We are cooperating in solving the problems of teaching science and mathematics to meet the future needs of our boys and girls.

The Central Association of Science and Mathematics Teachers offers an excellent opportunity for teachers to keep up to date through the annual convention and the Journal, SCHOOL SCIENCE AND MATHEMATICS. Every member of the Association who is interested in the future of science and mathematics teaching should try to get ***at least one new member for the organization in 1944***. Let's all pull together.

EMIL L. MASSEY, ***President***

Annual Meeting — *December 1 and 2, 1944*

ELECTROMAGNETIC RADIATIONS IN WAR AND PEACE

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This article is a condensed synopsis of lecture and black-light demonstration at the annual meeting of the Central Association of Science and Mathematics Teachers, Chicago, 1943.

In bringing to you an interesting diversion in the contemplation of *Electronics*, as a new science for a new world, I feel somewhat like the old preacher in the deep South who told his congregation that "explaining the Love of God was like trying to measure the immeasurable, fathom the fathomless and unscrew the inscrutable." Hence, the subject of "*Electromagnetic Radiations*" would seem to present a formidable mental barrier to all but the initiated. However, to the members of the Central Association of Science and Mathematics Teachers, an analysis of that term will quickly be understood as meaning "*A Frontier Wilderness*" through which only a few trails have as yet been blazed.

These trails have already led the pioneers in research, through the maze of *radioactivity*, *ionization*, and the *electron*. These have rapidly expanded into their practical use in *radio*, *radar*, and *electronics*.

It is very intriguing to note the vision expressed by that understanding radionics engineer, Miss Elizabeth Kelsey of the Zenith Corporation, who says "these trails lead on, and on to a 'Promised Land,' and that mathematics will be the necessary equipment as a staff upon which to lean, while following these trails into the most cultural and intellectual developments that lie just ahead."

Permit the writer to be your guide, and we will start down these trails and lead far out toward the new frontiers, to give you a glimpse of the amazing things which are to come. I hope you will be inspired to return to your classes and be their guide into the realm of ultra high frequencies and black light. Soon, they too, may help to push back the frontiers a little further, until the mysterious and unknown of today becomes the practical and commonplace of tomorrow.

Even as a pilot would not dare the stratosphere without a chart, we now have one for modern research. We are all in-

debted to several of our own members for a very excellent and simple chart. It is really a trail map of that wilderness, with which a good guide could lecture to the same class for two years on the trails depicted here, and never lose 1% of student interest.

Let us start with the Spectrum. From the sun and from unidentified cosmic sources, there comes to this earth, at all times, all the energy necessary to support life. If this energy were increased or decreased, ever so slightly, all forms of life upon this earth would cease to exist unless, perchance, to reappear in some other form as evidenced by microbe monstrosities under tests. That some of these energies have to do with every phenomenon and state of being on this round earth of ours is the first by-path with which the metaphysicist may well concern himself. (Incidentally, speaking of a round earth, a teacher reported not long ago that she had asked her pupils, "What is the shape of the earth?" and one of them promptly replied, "The earth is in bad shape.")

Of all the "light rays" in the amazing spectrum as science now knows it, only a very small segment encompasses the prime colors of the visible spectrum as our fathers and grandfathers knew it. That comprised their entire knowledge of light. Today, with our modern supersensitive film and electroscopes we have found six times as much *light* below the red end, and three times as much above the violet end. Of course, it is *black light* whether that invisible ray lies in the true ultraviolet and beyond, or in the true infrared or below. We only "see" it by its effect upon something else. That brings us to a knowledge of "vibrations" or wave length. When we step out of the realm of the visible and enter the "black-light" of the ultraviolet, we observe no piercing beam of brilliance. All is dark. The human eye is unable to accept the short vibratory wave length. Persistence would result in permanent blindness, even to daylight. We can, however, observe the stunning effect of that short wave-length radiation upon certain other things which do respond in a manner in which our retina does not. Mineral oils and vaseline will seem to "glow" as though by internal fire. "Fluorescent" we call them. Certain rocks respond in amazing beauty of deep rich color (many colors sometimes in a single specimen). This color is not "reflected" from any source, but rather induced light, emitted from the rock, while exposed to the action of the impinging force of the short-wave ray. It will change its in-

tensity or shade with any change of frequency in the activating black-light beam.

Here opens another by-path of greatest industrial importance. Scheelite, is a valuable tungsten-bearing ore. It looks like any common rock in ordinary light, but will fluoresce in brilliant orange or golden color, gleaming like a precious jewel in the darkness of night or down in the mines when exposed to the black-light rays of the new "Mineralight." This invisible beam modality was invented by Mr. Warren. His Ultra Violet Products Research Laboratories in Los Angeles, now list 42 different mineralized valuable ores. The modern "bindlestiff" carries this Mineralight, with a battery on his back, and now does all his prospecting at night! A word of caution however! If you are out prowling the desert floor prospecting with a Mineralight in the eerie darkness, and suddenly discover a patch of brilliant yellow, possibly as large as the palm of your hand, don't reach right down and pick it up at once. Kick it first. If it runs away it was a scorpion! Horned toads and certain lizards are sometimes quite fluorescent and look very beautiful, going the other way!

Other black-light or electromagnetic radiations like the little known "Grenz Ray" will kill any disease germ with which it comes in contact! Inspire some of your students to experiment in the production of this ray (about 2,400 to 2,900 A. U.) and soon they will give the world a germacidal or microbe lethal modality to use on the battle front or in the hospital, and prevent infection in open accidental wounds or incisions.

The Röntgen Ray, the next shorter known radiation has long been useful in penetrating the comparably porous substances we know as "opaque" to our limited vision. In this band, it will be remembered, that very short-time radiations of this X-ray, can be therapeutic; while long exposures of the same ray can be lethal. Remember that. It has much to do with the next band we designate as the Gamma Ray. Here is a real secret. For sure it is little known. This writer is prepared, with many years of experimentation, to prove that *small quantities of radium, will stimulate life!* It is only comparably large quantities, or long exposures of radium that will cause destruction of tissue, or death. So remember that, as we step over into the next band where Dr. Robert A. Millikan and Dr. Arthur Compton have isolated the "Cosmic Death Ray." Here you will perceive at once how this extremely short wave length, far beyond that of

radium, would be instantly lethal to human life, but let's look at its industrial and commercial applications.

Such an intensified and directed electromagnetic ray, concentrated beyond all mitigating or neutralizing rays, would instantly ionize the area of radiation. What does that mean? Just this. It is a discovery! A war secret that has not yet been admitted to the council of the combat forces. (And let's hope the enemy does not read this and act first, as they did with the secrets of Radar.) You are well aware that any internal combustion engine acquires its power by the instantaneous ignition of the explosive vapor in the cylinder, by a "hot spark" across the terminals of the spark plug. Well, if that area between those terminals is ionized there will be no spark! No power! The internal combustion engine on the tank or plane would be rendered dead! The cosmic ray can penetrate the engine block like water through a sponge! Therefore, that nation which *first* perfects a directional concentrated cosmic ray (and keeps the secret) will rule the world! It would be projected, like an invisible wall around a city, through which no airplane could fly! The ignition system would be shorted on the engine and down would crash the ship. (Then the other fellow would build a Diesel Engine plane which has no spark plugs, and come right on through again!)

The incredible speed of electronic energy in cosmic rays however, has an even greater peace-time job to do. Already we have seen the value of speed by the electron. The cyclotron at the California Institute of Technology is such an electron racetrack. It is natural that Dr. Lawrence there, would not be pleased for anyone to expose their experiments in transmutation! But here is a new trail down which to start your students in exploration! Remember this. There is only one more electron per nucleus in the structure of mercury, than there is in the nucleur structure of gold! Can the cosmic ray knock that one out? What does the Prophet Isaiah mean when he warns that day will come when men will cast their gold to the moles and to the bats.

But don't worry. We will still have time for an electronic sandwich! You say the bread is reinforced with vitamin; is made with irriadiated milk (more assured vitamin): the chicken and its feed is irradiated with ultraviolet while the hens eat at night (more vitamin). Now Dr. Findley D. John, the Chicago physician who is playing with physiological miracles every day, de-

clares that "vitamins are only radiant energy of different wave length!" Well, there is another by-path in the maze of trails for student youth to investigate. Maybe somewhere down through this jungle of electromagnetic radiations they will find the real fountain of youth.

Let's look at the other end of the spectrum. The pure infrared ray is also a black-light. Here is an electromagnetic radiation which puts the green in the grass and the color in our cheeks (most of the time.) With this ray photographs may be taken in total darkness with the clarity of a sunlight snap, and the one so photographed would be totally unaware! For tracing criminals and stolen autos, these new eyes of the mechanical robots are automatically taking pictures of every car and its occupants that pass in daylight, fog or darkness, at certain important cross roads.

Our Reconnaissance planes of the Signal Corps now use special infrared film which utilizes only that part of our daylight radiations to photograph enemy territory through mist and always bring out much detail unseen by the unaided eye. Physicians have infrared modalities which enlarge the capillaries, increase the local flow of blood, dissipate congestion and thereby promptly relieve pain.

Further along this infrared trail, there is another by-path Very intriguing! Remember when the sun was high last summer, and you thought the intense heat came from the sun? Well, it didn't! This infrared ray from the sun, passed the moon, to leave it cold, and came on down here to burn the sands of the desert! How come? There is very little air around the moon. Therefore very little resistance. There is plenty of air here. The more air, the more resistance; hence the more kinetic energy is created by this resistance, therefore—more heat. Out in Southern California stands Mt. Whitney with its snow capped peak in a temperature below freezing. You can see it, from the floor of Death Valley where it registers 134 in the shade, and no shade! What a whale of a difference that last couple miles of air made in the infrared ray's journey from the sun! The energy of resistance created a heat so dry that one's tissues would dehydrate and mineral salts be reduced to a point of death, in a matter of hours; unless you are prepared to fight it out by careful restoration. Of course in winter the angle of incidence reduces the impact. Start your students down that by-path, off this infrared trail. We need better dehydrating machines for every kitchen

now. Don't discourage them if they want to develop and experiment with these invisible elements of sunshine, by using it over the entire home in winter or over the whole village, for that matter. Otherwise, it's going to be cold around here next winter!

Consider now, the Hertzian band, which comes next in this parade of the electromagnetic radiations. It is between the radio band and the infrared band. It offers the greatest unexplored area for experimenting. Ultra ultra-high frequency is creeping into it from one side, and longer infrared rays on the other. Already it is reported in our *Proceedings of the Institute of Radio Engineers* that U. U. H. F. radio waves are approaching heat! Open this trail for your students also. Maybe they will send us heat by radio so that we may pick it up in every room, on a receiver, equipped with Glowbars of carborundum and iron! What need will the next generation have for coal as a heating agent? Please page Mr. John L. Lewis!

We have now come far, far down the spectrum, to the very highest U. H. F. of radio; and that is where *radar* comes in. It is also where this writer goes *out*. Not because he cannot tell it, but because he dare not. For the duration at least and even then it is questionable if it should all be told. This writer's work in the secret "restricted" laboratory of the U. S. Army Signal Corps, prompts him to greatest caution for the sake of victory.

It is no secret to tell you that we do "scramble" field messages so that all the linguists in the world could not interpret them, but which are picked up and unscrambled into perfectly good English again for the one and only receiver at General Headquarters. What a mess of jargon that really is on the beam, but how wonderful the good old "United States" sounds again when it finally reaches that one receiver.

As for the radio band you are all quite familiar with that which we have today. What we are going to have tomorrow is something else. Imagine inviting a string quartet, your favorite singer or entertainer, right into your home! Frequency modulated radio service will be just like that! Do you wish to *see* them as well? Turn on the television dial. The illusion of their actual presence will be complete, visually and audibly as though they were right in your room. At the American Television Institute the writer has watched a fourteen inch square animated electronic picture of action as plainly as though looking out the window. Up to now it is a "silent" black and white with de-

scription by a narrator. Direct your students down this trail also. There is gold in these "jungles." Hurry them out to help us produce these animated electrons in all the natural colors with syncopated sound effects. I could tell you how television works, but that might be revealing something about radar.

This simple outline is passed on to the members of the Central Association of Mathematics Teachers in the same spirit that the pony express rider once passed on his mail to the next relay. It is hoped that you will inspire your young mathematics and science students to take up the work where we leave off and clear this frontier jungle of its gremlins to perfect the things we hope for. No true scientist will develop a lethal instrument only for destruction, but he ever fears his inventions may be prostituted, even as the airplane today. These are the trails however, that will lead into the highest cultural and intellectual developments that are just ahead of us. Radionics and electronics will make our recent electrical age look like the "horse and buggy days" in comparison.

CAPTURED GERMAN TIRES TESTED SHOW NONE ENTIRELY OF SYNTHETIC RUBBER

Captured German army tires analyzed here are found to contain some natural rubber, and are not made entirely of synthetic rubber as commonly reported.

Four American scientists, working in the Research laboratories of the American Cyanamid Company, developed two methods of detecting natural and synthetic rubber in tires and other materials. All German tires examined by them contained natural rubber in varying quantities.

Of ten tire treads, one was wholly plantation rubber, and nine were pure Buna S, the synthetic butadiene-styrene rubber on which the Germans presumably depend principally. Of ten carcasses, all contained from 20% to 100% rubber. The tubes were 75% to 100% natural rubber.

The two methods developed for detecting natural and synthetic rubber and determining the proportion of each kind in a tire or other article are the result of two years of research, a report to the American Chemical Society states. One is measurement by the phosphorus content, the other is by use of infra-red light.

During growth, natural rubber trees and plants acquire minerals from the soil. Among these minerals is phosphorus. Some phosphorus gets into the rubber produced. Synthetic rubber has little or none of it. The amount of phosphorus in rubber can be measured by ultraviolet spectrochemical analysis.

The second method is by study of infra-red spectra. This determines what substances are present by the way they absorb infra-red radiations—light of the longest wavelengths. Each type of rubber molecules produces a different spectrum. A careful method was developed, to separate the pure rubber from the tire before making such tests.

PHYSICS FOR MEN IN OR ABOUT TO ENTER MILITARY SERVICE

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It is now generally agreed that physics has a definite place in the training of men for military service. The value of physics in carrying on the war effort is unquestioned and, I think, universally accepted. The conditions under which our present students learn and apply physical principles are sufficiently novel and unique to justify giving some time and serious thought to problems in connection with the study of physics by men about to enter the military service. In peace time, if a man did not fully understand the implications of a physical principle, he had ample time and opportunity to inform himself before making an application or a decision. Imperfect understanding could at worst, result in the failure of some machine, bridge, or roadway attended by financial loss. In the service, inability to quickly grasp the full import of a simple law of nature may result in a casualty not only of a single individual but possibly of a very large number of men. The motif of all I have to say might be summed up in a sentence. The value of a man in military service depends on his ability to promptly and correctly grasp a situation and to act at once for the greatest good to the largest number. For our purpose this means that a man in military service must promptly and correctly recognize the principles underlying natural phenomena and be able to respond with an effective solution should a problem arise.

How can teachers of physics help men in their courses acquire this ability? Any answer that I may attempt cannot be final. I have been tempted to offer some suggests only because of my genuine interest in the work and in light of my experience with the V-12 program, with the, now discontinued, Civilian Pilot Training Service, and with the Air Service in the last war.

The question may well be considered under two heads (a) Teacher and pupil or student (b) Subject matter.

One might consider the selection, training, refreshing etc. of teachers. We shall not concern ourselves with that phase, but shall assume that the best qualified teachers available are employed. The point I wish to make with respect to teachers is that they must be unusually sympathetic and understanding in their contact with the men under their direction. This is not to

be interpreted as a lack of discipline or a general lowering of over all standards. One frequently hears expressed ridicule and sarcasm at the "dumb clucks without mathematical background who ought not to have been placed in a physics class." This I deplore. I believe that physics has something to offer these men, each in his own measure. It should be the spirit of the teacher to be helpful in the learning process. These are troubled times for the young man. In many cases he is not taking physics by choice—except in so far as he has been told and believes that it has something to offer. He is impatient—more than likely he did not join the marines to go to school—he joined up to get into action. The teacher will, in general, not be able to spend much time with these men as individuals. It has been my experience that they are surprisingly frank, blunt, and sincere. The teacher must upon every occasion be equally to the point with an understanding of the situation.

These students have a minimum time for preparation. It is up to the teacher to see that classes are alert and that the learning process goes on effectively in the classroom. Students and teacher should realize that certain things must be learned and that this must be done in the shortest possible time. The teacher can aid in this by presenting the essentials in a well organized, objective and visualized manner. Men in the service training schools and in the service must be able to visualize the physics they use. I believe one of the things we will copy and retain in our schools after the war is the visual and objective presentation of subject matter in the class room so effectively developed by the better service command training schools. Physics has always been presented by demonstration methods but I think we can and will improve in this direction.

Now as to the subject matter. Regardless of what is presented, much or little, it must be illustrated and vitalized with data, cases, and problems drawn from fields of immediate concern to the student. Why calculate the amount of gold in the crown of an ancient king when one can use the same principle in calculating how little cork will keep a 160 pound man afloat in sea water? Why speak abstractly of momentum, impulse, and impulsive forces when we have the landing gear of an airplane cracked up because the pilot did not "level off" enough before setting the plane down? Why speak of cream separators and the apple on the end of a string when the dive bomber is in danger of losing a wing or having the pilot "black out" when pulling out of a

dive? Do not give an undue amount of time to the astatic galvanometer system and overlook the device which "licked" the magnetic mine. The "bazooka" is infinitely more vital than a projected trip to the moon in a rocket ship. You can add to this list as well as I.

The thing that has troubled me most is where to get quantitative and reliable data to give these problems their maximum appeal and usefulness. At present I can give no specific answer. The military as an organization has been reluctant to give certain data—even obsolete—to civilian teachers. I have been collecting such material for some time and find that much is available but in widely scattered sources. For teachers of students not yet in the service I am inclined to suggest a kind of student clipping bureau—scrapbook combination. It is surprising how much really valid information is to be found in news items and in advertisements by the larger industrial concerns. This forms an excellent starting point for the discussion of physical principles. Perhaps a word of caution is in order because some of the results will be almost unbelievable and we must not allow perfectly good physics to become fantastic and merely spectacular. I dare say most of you are surprised to know that an eight inch cube of cork will keep a 160 pound man afloat, that the pressure in a Garand rifle is upwards of 50,000 pounds per square inch, that the acceleration of its bullet is more than a million feet per second per second, that a cubic yard of air weighs over two pounds, that 10,000 pounds of air passes every hour into the carburetor of each motor in the Flying Fortress, that for a given plane the runway at Denver must be almost twice as long for a "take off" as at sea level, that "take off" in the hot desert air requires five or ten per cent more speed than in cool climates. These and many more examples may be treated with fairly elementary physics.

A few words with respect to units. Men in the service will come in contact with both the metric and British engineering units as well as with certain nautical terms. It is, therefore, important that we include drill in conversion factors of length, mass, power, pressure, temperature, etc. Aeronautical engineers use the slug as the unit of mass. (The density of air is 0.002378 slug per cubic foot at 59°F. and 29.92 inches of mercury.) Absolute Fahrenheit or degrees Rankine are also used. (The "ice point" is 459.4°R.) Units and conversion factors should be presented not as abstract memory exercises but should give the

student a practical, familiar visual concept of the quantity involved. Let him construct a box that will hold eight gallons of gasoline, let him put a 37 mm. plug in a 1.5 inch hole or vice versa, compare a 90 mm. and a three or four inch disk. Let him do this with his hands—not just with compass and paper. Call attention to the relationship between horse power, "man power," and the 75 watt lamp on his study desk.

Reference to physical and physiological effects on the individual always brings an attentive response. The "black out" or "grey out" of the dive bomber is due to the inability of the heart to lift, blood to the brain against a centrifugal reaction of more than "5g." Sight is then temporarily lost within five seconds. The muscles of the neck are not able to raise the bowed head when the upward acceleration is more than six times that of gravity. The surface area of the average man is about twenty square feet. Hence, the total force on the sea diver is surprisingly large; also depth limits are set for rescue with the Mumson lung.

In our teaching we must not neglect accuracy and exact quantitative relationships. However, there are times when men in the service must have quick ready and approximate information. At such times a liter is a little more than a quart, a kilogram a bit more than two pounds, a yard just short of a meter, an atmosphere about 15 pounds per square inch or roughly a thousand millibars. Again it is most essential to know that doubling the speed of a body increases its kinetic energy by a factor of four. Increasing the speed of a plane by a factor of two requires stepping up the horse power by a factor of four to eight. Have the student learn that varying one quantity may or may not have a significant effect on another.

Time does not permit giving examples in the other branches of physics, but I assure you that heat, light, and electricity are equally rich in their applications in this field.

In our teaching we cannot make soldiers, sailors, or pilots but we can make these men more intelligent in the work they do. In closing I cannot refrain from expressing the hope and warning that if we make physics, intelligible, vital and useful—yes, perhaps life saving—to these men, they will recognize its value when they return to their peace time activities. Then will we see a continued demand for our work, our men, our subject. On the other hand if we fail to touch these men I am afraid physics will again be looked upon as a subject too difficult, too

impractical, and too mathematically abstract to be used or understood by any but the long haired scientist.

By doing a "bang up" good job with these men we do a good turn to our country's war effort, to the men themselves, and to science in general.

THE INTERPRETATION OF CERTAIN NOTATIONS IN DECIMALS

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A generation or two ago one found many problems in converting to decimals which introduced such notations as $2.34\frac{2}{3}$. These problems are much less frequent in present day arithmetics yet the notation is sometimes encountered in college work, especially in connection with problems involving compound interest.

For example, if one wishes the effective rate equivalent to a nominal rate of 4% compounded monthly, the value 0.00333 is an approximation while the value $0.00\frac{1}{3}$ is exact. To determine the amount of a pawnbroker's loan for two years at 20% nominal interest compounded monthly, use may be made of the factor $(1.01\frac{2}{3})^{24}$.

Unfortunately many texts which use such notations as these fail to give any explanation of the meaning. Perhaps it is felt unnecessary, yet students with considerable mathematical background have been puzzled by the notation, in particular by such forms as $1.00\frac{1}{3}$. It must be stressed that just as $4\frac{1}{3}$ means four units and one-third of a unit, $0.02\frac{1}{3}$ means two hundredths and one-third of a hundredth. Hence $1.00\frac{1}{3}$ means one unit and one-third of a hundredth of a unit and not, as students are likely to assume, one unit and one-third of a thousandth of a unit. This mistake seems to arise from the reasoning that because the $\frac{1}{3}$ appears in the thousandth's place, its value is one-third of a thousandth. The correct meaning is clarified if it is shown that $1.00\frac{1}{3}$ might arise from $1+0.01/3$ which is $1+1/300$ or $1+\frac{1}{3}(1/100)$.

It is possible to avoid the use of such expressions by the use of approximate values. However $(1.03\frac{1}{3})^n$ is not equal to $(1.033)^n$ as may be verified by using $n=2$. Since n may be quite large and the result may be multiplied by a number as large as 10,000

the discrepancy is likely to be important and this method of evading the issue is unsatisfactory. The use of compound interest tables may be another method of avoiding the issue, but tables are not always available for the particular problem. If tables are not available, the tendency seems to be to use such forms as $1.00\frac{1}{3}$ or $1+0.01/3$. An alternative method, less frequently seen, would be to use $3.01/3$.

The instructor should remember that if he employs a notation such as $1.00\frac{5}{12}$ it is likely to be new and hence confusing to the student. Time spent in explanation may be well spent. As an interesting curiosity one may note the expression $0.\frac{1}{3}$. Unless the instructor has thought about the matter a student's question as to its meaning may be embarassing. Following our previous discussion, the theoretical value would be one-third of a unit: actually since there is a much simpler way of expressing this value the notation has never come into use. A rather extensive search through a university library developed only one brief reference to expressions such as $3.\frac{1}{2}$ which are probably "illegitimate."

TWO-WAY ELECTRONIC TELEPHONE SYSTEM INSTALLED IN FREIGHT LOCOMOTIVES

A two-way electronic train telephone system which permits freight conductors and engineers to talk with each other or with block operators is now in operation on the 67-mile Belvidere-Delaware branch of the Pennsylvania Railroad, running northward from Trenton.

This unique system, the first to be established up to the present time, will be used on freight trains only until more thoroughly tested. Installation of the necessary equipment has been made on ten locomotives and in ten cabin cars. It has also been made in one block station, at Frenchtown, N. J., and is under way in another block station at Trenton.

High-frequency alternating currents are used in the new system. They are transmitted along the rails, and also along wires on poles parallel to the track. They are termed "carrier" currents. They have impressed upon them the impulses of the telephone currents produced by talking into the telephone instruments. These electrical impulses are transformed back into sound by the receiving sets in the locomotives, cabs or block station.

The system will be used at present for operation purposes only. Train crews will be able to report to block station operators and to get orders from them. Conductors and engineers will be able to talk to each other at will, and also to communicate with other trains within several miles' distance.

This new train communication system was produced in collaboration with the Union Switch and Signal Company, following several years of intensive experimentation and development. Further installations are planned after this first has been given a thorough trial in practical operation.

GENERATING SOME HIGHER PLANE CURVES

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Students in trigonometry and in analytic geometry are required to plot higher plane curves using equations in rectangular and in polar coordinates. The work is considerably enlived if, instead of these equations being presented as finished products to be graphed, conditions governing the motion of the generating point are given, from which the curves can be plotted and finally, the equations derived.

A set of conditions which will generate a large family of higher plane curves will be described. Let two equal circles, K and M, of radius, a, pass through a fixed point, O. Let the centers of circles K and M revolve about O at rates r and s. Plot the locus of P, the other point of intersection of the revolving circles, K and M. When the circles K and M coincide, let P be taken as the point diametrically opposite O.

To form a grid on which the moving point, P, may be easily located, draw a circle with center O and radius a. Divide its circumference with a protractor into thirty-six equal parts. With these points of division as center, draw thirty-six circles of radius a. Number the centers and the corresponding circumferences of these circles from 0 to 35. By using various colored pencils, the same grid may be used for as many as four different exercises in discovering the graphs of members of the above mentioned family of curves.

The equation of any member of this family of curves is easily derived. In figure one, let $OH = OK = OM = a$. Let K and M rotate about O in a counter clockwise direction. Let H be one of the points where K and M coincide. At any instant, let $\angle KOH = b$, and $\angle MOH = c$. Then $\angle POK = (c-b)/2$ and $OP = 2a \cos (c-b)/2$. Now in polar coordinates, $\rho = OP$ and $\theta = \angle POH = (c+b)/2$, so that the locus of P is given in polar coordinates, by the equation,

$$\rho = 2a \cos \left(\frac{c-b}{c+b}\right)\theta. \tag{1}$$

If either K or M revolves about O in a clockwise direction,or if K and M both revolve about O in a clockwise direction, then, if as is usually done, such clockwise rotation is considered to be

negative, it is easily shown that equation (1) still holds. Since $\cos(-\theta)=\cos\theta$, there is no need to fix either c or b as the greater quantity.

Transforming from polar coordinates to rectangular coordinates gives the equations,

$$x=\rho\cos\theta=2a\cos\left(\frac{c-b}{c+b}\right)\theta\cos\theta \quad \text{and}$$

$$y=\rho\sin\theta=2a\cos\left(\frac{c-b}{c+b}\right)\theta\sin\theta.$$

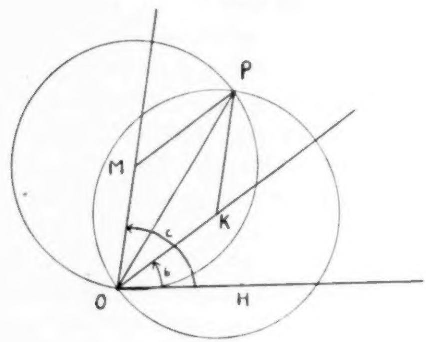

FIG. 1.

Since it would be tedious to obtain x and y from products of trigonometric functions, these equations may be transformed into

$$\begin{aligned} x&=a\left[\cos\left(\frac{2c\theta}{c+b}\right)+\cos\left(\frac{2b\theta}{c+b}\right)\right] \\ y&=a\left[\sin\left(\frac{2c\theta}{c+b}\right)+\sin\left(\frac{2b\theta}{c+b}\right)\right]. \end{aligned} \tag{2}$$

Let $2c\theta/(c+b)=t$ and let $b/c=w$, then $2b\theta/(c+b)=wt$. Substituting these values in (2), the parametric equations in rectangular coordinates become

$$\begin{aligned} x&=a(\cos t+\cos wt) \\ y&=a(\sin t+\sin wt). \end{aligned} \tag{3}$$

The equation in polar coordinates given in (1), or the parametric equations in rectangular coordinates given in (3) may be used for practice in plotting the curves previously found through the above mentioned locus exercises.

A discussion of some of the properties of the curves in this family may be of interest. In figure one, let the fraction b/c reduce to the fraction d/e where d and e are relatively prime positive or negative integers. Then it is easily shown, using the same technique as in clock problems, that circles K and M will coincide again at some point H' such that

$$\angle HOH' = \frac{2e\pi}{e-d} \quad \text{and} \quad \angle HOH' = \frac{2d\pi}{e-d}$$

where these two values of the angle differ by 2π. Since the numerator and denominator of either fraction are relatively prime numbers, then there are $|e-d|$ distinct points at which circles K and M coincide, and therefore an equal number of points at which they are tangent. Thus the graph of any member of the family of curves defined by equation (1) will have $|e-d|$ fundamental loops in it.

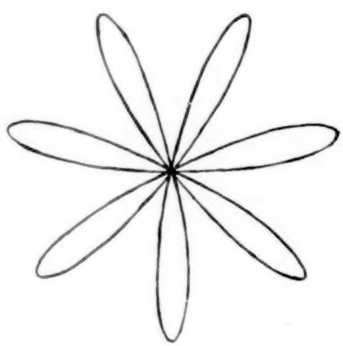

FIG. 2.

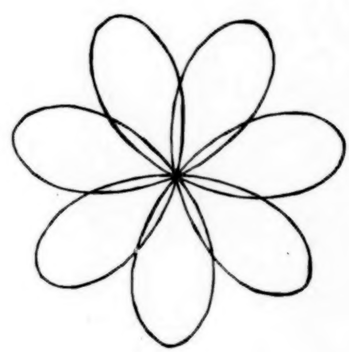

FIG. 3.

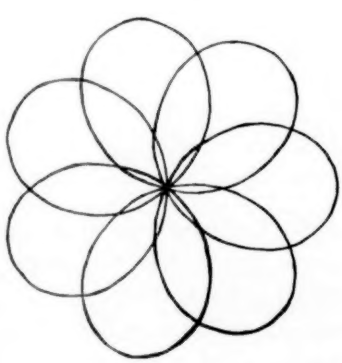

FIG. 4.

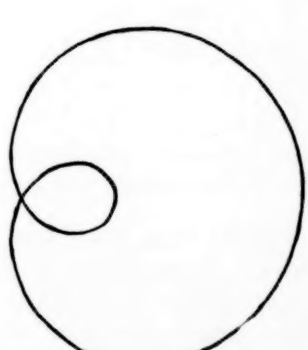

FIG. 5.

The following table shows the relation between the number of fundamental loops in a curve of this family and its equation. In this table $|e-d|$ goes from one to seven. As before, d and e

number of loops $=\|e-d\|$	e	d	$\frac{c-b}{c+b}$ in lowest terms	formula
1	2	1	1/3	$\rho=2a\cos(1/3)\theta$
1	3	2	1/5	$\rho=2a\cos(1/5)\theta$
1	4	3	1/7	$\rho=2a\cos(1/7)\theta$
etc.	etc.	etc.	etc.	etc.
2	3	1	1/2	$\rho=2a\cos(1/2)\theta$
2	5	3	1/4	$\rho=2a\cos(1/4)\theta$
2	7	5	1/6	$\rho=2a\cos(1/6)\theta$
etc.	etc.	etc.	etc.	etc.
3	2	−1	3	$\rho=2a\cos 3\theta$
3	4	1	3/5	$\rho=2a\cos(3/5)\theta$
3	5	2	3/7	$\rho=2a\cos(3/7)\theta$
3	7	4	3/11	$\rho=2a\cos(3/11)\theta$
etc.	etc.	etc.	etc.	etc.
4	3	−1	2	$\rho=2a\cos 2\theta$
4	5	1	2/3	$\rho=2a\cos(2/3)\theta$
4	7	3	2/5	$\rho=2a\cos(2/5)\theta$
4	9	5	2/7	$\rho=2a\cos(2/7)\theta$
etc.	etc.	etc.	etc.	etc.
5	3	−2	5	$\rho=2a\cos 5\theta$
5	4	−1	5/3	$\rho=2a\cos(5/3)\theta$
5	6	1	5/7	$\rho=2a\cos(5/7)\theta$
5	7	2	5/9	$\rho=2a\cos(5/9)\theta$
etc.	etc.	etc.	etc.	etc.
6	5	−1	3/2	$\rho=2a\cos(3/2)\theta$
6	7	1	3/4	$\rho=2a\cos(3/4)\theta$
6	11	5	3/8	$\rho=2a\cos(3/8)\theta$
etc.	etc.	etc.	etc.	etc.
7	4	−3	7	$\rho=2a\cos 7\theta$
7	5	−2	7/3	$\rho=2a\cos(7/3)\theta$
7	6	−1	7/5	$\rho=2a\cos(7/5)\theta$
7	8	1	7/9	$\rho=2a\cos(7/9)\theta$
7	9	2	7/11	$\rho=2a\cos(7/11)\theta$
7	10	3	7/13	$\rho=2a\cos(7/13)\theta$
etc.	etc.	etc.	etc.	etc.

are derived from the relation $(b/c)=(d/e)$ where d and e are relatively prime. Since no new curves are introduced when b and c are interchanged, b is arbitrarily kept less than c.

Since d and e are relatively prime, it is easily shown that if $(e-d)$ is an even number, then *either* $(e-d)$ or $(e+d)$ is divisible by *four*. Thus if $(c-b)/(c+b)$ reduces to some fraction in lowest

terms, which has an *even* number as the numerator or the denominator, then the number of loops will be *twice* the numerator; in all other cases, the number of loops is equal to the numerator of the reduced fraction.

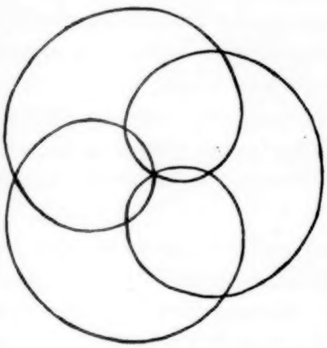

FIG. 6.

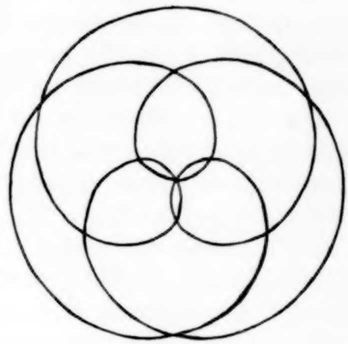

FIG. 7.

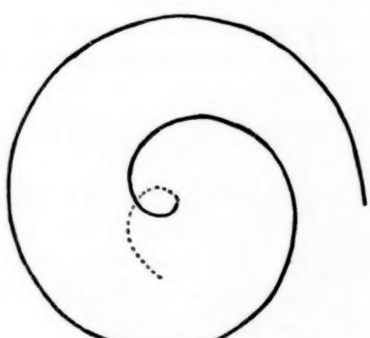

FIG. 8.

It will be noticed in plotting the graphs that when $(c-b) > (c+b)$ the loops are external loops, and when $(c-b) < (c+b)$ the loops are internal loops. Finally, if p is an odd prime, there are $(p-1)/2$ curves with p external loops and an infinite number of curves with p internal loops in the family of curves defined by equation (1).

The curves of form $\rho = 2a \cos n\theta$, n an integer, are at once recognized as the various roses. These need no further discussion in classroom work except for the reason why the number of loops is doubled when n is an even number. Generalized roses with seven loops are shown in figures two, three, and four. The

equations of the curves are respectively, $\rho=2a\cos 7\theta$, $\rho=2a\cos(7/3)\theta$, and $\rho=2a\cos(7/5)\theta$.

The curve, $\rho=2a\cos(1/3)\theta$, shown in figure five, is the familiar limaçon, $\rho=a(2\cos\theta+1)$. This is easily shown by transforming to rectangular coordinates, moving the origin to $(-a,0)$, and transforming back to polar coordinates. Incidently, this shows the limaçon to be one of the many higher plane curves which may be used to trisect an angle.

The curves with several internal loops are interesting. Figures six and seven show two of the infinite number of curves with three internal loops. Their equations are respectively, $\rho=2a\cos(3/5)\theta$ and $\rho=2a\cos(3/7)\theta$.

The curves of the form $\rho=2a\cos(1/n)\theta$, n an *odd* integer, are all double spirals. The generating point spirals in to the origin through n quadrants, then spirals out again through the next n quadrants, and with increasing θ retraces the same path an infinite number of times. The curve in figure eight is $\rho=2a\cos(1/7)\theta$. The inward spiral is drawn solid and the outward spiral, shown by the dotted line, is only partly drawn. In rectangular coordinates, the parametric equations of this spiral are:

$$x=a\left(\cos t+\cos\frac{6t}{7}\right),\qquad y=a\left(\sin t+\sin\frac{6t}{7}\right).$$

The curves shown in figures two to eight are only a representative sampling of those listed in the preceding table. The teacher will find many other interesting curves in this table for regular or extra assignment both in discovering the locus and in plotting the curve from the equation.

ANTHRACITE COAL ASHES RECOMMENDED FOR ROOTING PLANT CUTTINGS

Anthracite coal ashes are an excellent material in which to set plant cuttings while they are striking root, states Miss Mildred P. Mauldin of the seed testing laboratory of the U. S. Soil Conservation Service here, in a communication to Science.

Sifted hard coal ashes were used on a large scale for this purpose by her father, who for many years operated a wholesale cut-flower business in New York. Cuttings thus rooted were exceptionally free from diseases, especially from damping-off, a fungus plague that sometimes wipes out whole benchfuls of young plants. The ash-rooted cuttings, Miss Mauldin adds, produced large clumps of roots and carried throughout their lives much of the vigor with which they started.

AN ELEMENTARY SCIENCE PROGRAM FOR THE AIR AGE

Edward P. Powers
Public Schools, Northport, New York

Most farsighted educators will agree that the sudden, destructive power of war has carried along with it certain compensations which are now being felt, and, which will affect the world of the future. In the twisted surroundings of hate and blood they stand as a beacon light for the future welfare and happiness of man. One of the greatest of these is man's conquest of the skies. He has taken wings. His future civilization will be built around the keystone of aviation, for certainly the war has brought about tremendous advances in airplane development. In the roar of mighty bombers over Europe there emerges the vision of great fleets of freight and passenger planes shuttling man and his goods through the skies to distant parts of the world.

Aviation gives every promise of being an industry of large specifications. With the airplane, new trade routes will be drawn, unlimited by natural obstructions, distance or time. New lands, ripe with productive wealth, will be made available. Momentous changes will take place in our industrial organizations. People will move about our planet with greater freedom. Old prejudices will disappear. Boundaries will shrink as world organization becomes a neighborly affair. One of the greatest single factors in this movement, has been the development of the airplane—improved over a period of two wars as a terrible weapon of destruction, but giving promise of being a potent factor in the organization and maintenance of a better world.

The children we teach today will play an important part in this organization of the world. It is they who will build and maintain the sky ships of the future. They will be the foundation stone upon which American industrial leadership shall rest.

Realizing this, we in the elementary school, believe that a new and important emphasis should be placed on the teaching of science. These changes are already occurring in our secondary schools, but our elementary schools are lagging behind. It is not too early to begin, for it is at this level that interests are developed which often carry a child into his life's work. It is at this age that enthusiasms are most easily stirred. Carefully

nurtured, these enthusiasms become the raw material that will manufacture our post-war hopes. Properly taught, fundamental principles of science will find beginnings in the roots of understanding.

In Northport, we are taking an experimental step which we hope will be one answer to the new challenge in science teaching. Since aviation will play an important part in the future we are attempting to teach our elementary science through the vehicle of aviation. Careful analysis of units generally taught on this level reveal many opportunities of demonstrating that the maintenance of aviation is vitally dependent on scientific understandings. When this becomes evident to the children we have taken a major step forward in arousing interest in the study of science.

We have set up our program so that our first unit for the year is an aviation unit. One of the first steps is to encourage the children to bring in model planes to build in the classroom. A specified date is set when this work is to be finished. Then a class exhibit of the planes completed is held. Children are very enthusiastic at this stage. It is at this point that the nature of their study of the year will be revealed to them.

After a general discussion about airplanes, which most certainly will be a lively one, the teacher may begin to ask them what scientific knowledge is needed so that planes may be built and flown. The units for the year such as Electricity, Magnetism, Heat, Astronomy, Light, Sound, Air, Photography, Simple Chemistry, Weather, Energy, and Water, in addition to many others should be well impressed upon the teacher's mind. Their relation to aviation should be studied out beforehand. By looking over each unit the teacher will readily see that most of them bear a direct relation to aviation maintenance. Any teacher who has taught elementary science will see that most of these units taught at this level are vital to aviation. It is wise then to jot down before the discussion all the possibilities of relating each unit to aviation.

Then, in the course of the discussion the children will bring up such points as the compass, storms, air pressure, metals, electrically controlled devices, winds, navigation by the stars and other points. After listing these knowledges needed, given by the pupils, the teacher can begin to group them into large topics such as Astronomy, Weather, etc. With this will follow an explanation that the class will study these units and try to

find out how important these sciences are to the development of aviation.

It follows that in the study of these units, presentation, theme, and objectives should be centered around aviation. Every opportunity should be utilized so as not to lose the relationship. Planes and plane pictures and diagrams should be in evidence in the room throughout the year. Every principle and concept developed should find its way to the airplane. How is this done? Let us take a sample unit.

After building their planes the children will be interested in what makes them fly. This develops the study of air. The teacher maps out the problems she would like to have solved. They are listed and the study begins. The problems are solved by experiments, research and reports, textbook study, and class demonstrations. In studying air pressure a number of experiments can be done with an electric fan and a paper wing mounted on a stand. By using smoke the air stream can be pictured. Air pressure experiments will help show the great force of air upon a wing. In learning that the higher we go the thinner the air becomes evident to the children why pilots wear oxygen masks. These and many other phases of the study of air bear direct relation to aviation physics.

Or, take the area of weather study. The teacher shows pictures of the damages wreaked by great storms. The talk swings to storms and pilots. She has stirred an interest in the weather. Therefore a study of weather is begun to determine how pilots are protected. The nature of the weather is investigated, amateur forecasting is undertaken, the function of the weather bureau is investigated, and the protections that the weather bureau gives aviation are studied. Surely a subject such as this will bring about a greater understanding of the problems and accomplishments of modern aviation.

These two units are typical of others in the entire elementary science field. But what overall principles should guide a teacher who desires to begin a program of this nature?

First, an appreciation of the fact that modern aviation is a direct result of the contributions of scientific research. Understanding this, the teacher investigates units of science, determines what areas of each study can be related to aviation, and then builds the large framework of each unit with these relationships as a primary objective of understanding.

Second, every use of experimentation and observation is

made. We blend our methods, of course, varying from class demonstrations, teacher demonstrations, individual and group research, discussion, and group projects. Wherever possible we have the children do the demonstration.

Third, a number of reference books are always present in the room, as well as a variety of textbooks. This helps to expedite research. We have well-equipped science rooms, but this is not essential. Where there is a lack of equipment it can be improvised, using pans, alcohol lamps, rubber, wood, tin cans, glass jars, and dozens of other materials.

Fourth, we find the best method is to set up our problems for each unit. We work into the problems correlations with aviation, and applications of principles to aviation. Then the problem is taught according to the method which fits the type of problems in the best way. Along with each problem we have listed whatever activities and experiments that will help solve it. We use these with a bibliography of books that treat that particular problem. This needs considerable preparation in advance, but it expedites the teaching of each problem. After the problem is solved it is discussed from the standpoint of aviation, and this provides many interesting and informative discussions. Then a short test is given on the problem, with always a question regarding its relation to the air age. We like to have the children take notes on the important ideas gathered from each problem. Each problem becomes a challenge. They may be assigned individually, by groups, or by the class as a whole. Children assigned to particular problems do the research, set up and perform the experiments which they find, or are suggested by the teacher. Then reports are given. Not all units lend themselves to this type of study however.

Fifth, we do not insist on mastery as much as we try to paint a broad picture of science in the modern world. In this case we have made a deep study of aviation and have found out through the year that science keeps aviation going. After the completion of this study the children have covered a number of areas. As you glance at a few of the studies which I have listed below, taken from science units, I am sure you will agree that the children who study them will be better prepared for a civilization that moves through the air.

1. Study of plane parts, construction, operation.
2. Air and air pressure.
3. Photography.

4. Magnetism and the compass.
5. The study of the stars.
6. Electricity and radio.
7. Simple chemistry of metals and food.
8. Weather forecasting.
9. The energy man uses.

NOTES FROM A MATHEMATICS CLASSROOM

Joseph A. Nyberg
Hyde Park High School, Chicago, Illinois

71. Stating the Theorems. Rereading the journals of ten or twenty years ago is always interesting, particularly the articles which suggest improvements in pedagogy. Have the suggestions won favor, or are teachers as slow to learn as some pupils are? M. M. S. Moriarty of the Holyoke (Mass.) High School in *The Mathematics Teacher* for May 1928 suggests some clearer statements of certain theorems of geometry and discusses the relative importance of others. I shall review some of them.

1. When stating the third congruence theorem should we say "If the sides of one triangle . . . ." or "If the three sides of one triangle . . . ." or "If three sides of one triangle . . . "? The first is the best; in the last form there is an implication that we are dealing with three of the three or more sides. (Compare these statements, for example, with: "If three sides and the included angles of a quadrilateral are equal respectively . . . ").

2. When bisecting a segment the radius that is used must be greater than half the segment, but the directions cannot state that we should use a radius greater than a quantity that has not been found. The segment itself will do as a radius; since this radius is sufficient but not necessary, the texts have attempted various other statements. Of the possible substitutes Moriarty suggests using a *sufficient* radius.

3. Since an angle is not an arc, the statement of how central and inscribed angles are related to their arcs always needs explaining. The suggested form is: "An inscribed angle equals one-half of the center angle that intercepts the same arc." (This is a problem for the class in semantics. We measure the capacity of a gasoline tank in gallons; but do we use a bucket that holds exactly one gallon, fill it with gasoline, empty it into the tank,

fill the bucket again, and so forth, or do we merely look at the numbers on a dial? Is not all measuring done by substituting one quantity for another?)

4. When stating the sum of the angles of a triangle, shall the unit of measure be a straight angle, a right angle, or a degree? Moriarty favors a right angle "since the right angle is a natural unit, and can be constructed easily by the pupil." (However, most texts now favor 180° as the sum.)

5. We should distinguish between "things equal to the same thing" and "things equal to equal things" so as to make the pupil more accurate in thought and expression.

6. "Parallel with" expresses the besideness of parallel lines while "parallel to" does not.

7. On the grounds that they are seldom used or have good substitutes, Moriarty would dispense with the following:

(a) Parallel sects intercepted by two parallel lines equal each other. The data give a parallelogram, and the opposite sides of a parallelogram equal each other.

(b) Theorems about angles whose sides are respectively parallel or respectively perpendicular.

(c) If the hypotenuse and an acute angle are equal respectively, . . . , the triangles are congruent.

(d) Triangles are similar if the sides of one are proportional to the sides of another. This plainly belongs with the exercises since it is not used again after being proved.

(e) Many of the corollaries that follow the sum of the angles of a triangle. Moriarty thinks three corollaries would be needed but does not state which three.

(f) A diagonal of a parallelogram forms with the sides equal triangles.

The article deserves rereading by all of us. Among my own aversions are such phrases as "strike an arc," "drop a perpendicular," "erect a perpendicular" and "lay off a line."

72. Learning $n/2$ Things Well. When minimum courses became part of our educational system the apology for them was the argument that it is better to learn well one-half of n things than to half learn n things. This assumes that we have n things of equal value, and that any part is typical of the whole. The assumption is wrong. Some educator should find a slogan or a descriptive phrase that will contrast the worthwhile, the valuable, the useful, the important, the significant parts of a course with the trivial, the useless, the petty, the paltry parts. For

want of such a slogan I shall contrast trivial with significant, and suggest the motto: *A small success with significant things is worth more than a large success with trivial things.* It is better to struggle with n significant things than to learn well $n/2$ trivial things. Or, it is better to fail with n significant tasks than to succeed with $n/2$ trivial tasks.

Consider, for example, the field of arithmetic. It has two divisions: (a) learning how to add, subtract, multiply, and divide, and (b) solving problems (in these we are not told which operation to perform). It is the second part which presents difficulties. In accordance with the $n/2$ theory, the emphasis in minimum courses is put on the first part since this contains the $n/2$ tasks that the pupil can learn to do well. But the significant part of arithmetic is the second part. One hundred per cent of (a) is useless unless it can be applied to (b). Of course (a) is necessary, and must precede (b), but it is not sufficient.

In pre-induction classes the difference is glaring. Pupils who are experts in computing do not know which operation to perform when confronted with the problem:

A kilometer is $\frac{5}{8}$ of a mile. A soldier walked 13 mi. How many kilometers did he walk?

And most of the class is lost with a problem like:

A gasoline tank is $\frac{7}{8}$ full: $\frac{3}{4}$ of this gasoline is used on a patrol, and at the end there are $10\frac{1}{2}$ gal. left. How much gasoline can this tank hold? (*Buchan's Aviation Mathematics.*)

If a class is limited to learning well $n/2$ things, then $n/4$ of these things should be chosen from the part (a) and $n/4$ chosen from part (b). If all $n/2$ are chosen from (a) the work is trivial instead of significant.

Likewise, in algebra there are two parts: (a) the operations, and (b) the applications of those operations to problems. The significant work is in (b). And it is better to struggle with (b), and to fail, than to limit the work to (a).

Perhaps the trouble is that teachers, like pupils, also prefer success with $n/2$ things to partial success with n things. Nothing is more discouraging than to give an examination and find that the pupils have learned little. On such occasions the teacher who has struggled with significant work needs a friend who will say, "Well done, faithful servant. 'Tis better to have tried and lost than never to have tried at all."

73. The Research Needed in Arithmetic. Most of the research in arithmetic has studied how best to learn computing; what we

need is research to develop techniques for teaching pupils how to select the correct operation. It seems ridiculous that there are people who need to be taught that a hammer, not a saw, is used to drive nails, and that a saw, not a screwdriver, is used to saw wood. But consider the above problem about the kilometers and miles. The pupil wonders: should 13 and $\frac{5}{8}$ be multiplied or divided? My advice to the pupil is:

If you are familiar with the things mentioned (teachers would say "if the concepts have meaning") but are puzzled about which operation to perform, try replacing each number with a simpler number. For example, if a kilometer equaled $\frac{1}{2}$ mile, and if the soldier walked 10 miles, could you solve the problem? Then the operation performed with the simpler numbers will be a clue to the correct operation for the complicated numbers.

74. The Use of Optical Illusions in Geometry. Almost every text in geometry contains a few optical illusions whose purpose is to show that we must not be misled by appearances. There is one disadvantage. While they teach that appearances are deceptive and that other evidence is needed, they also tend to make the pupil believe that we are interested in finding out whether or not certain statements are *true*. Later the teacher must remove this notion and emphasize that we are studying what conclusion *follows* from certain data. For example, we are not primarily studying whether or not certain triangles are congruent, but whether the congruence *follows* from the hypothesis; that is, what *causes* the congruence? To be consistent we should ask what causes the lines to be parallel when they do not seem to be parallel, and what causes lines in the illusion to appear unequal when they are not. Since these questions cannot well be answered I prefer to avoid any study of illusions.

We need constant reminders that in geometry we are not trying to prove that $c=d$. We are providing that $c=d$ is a logical conclusion from $a=b$. For this reason I discussed in the NOTES, Feb. 1942, whether it is proper to state a theorem or exercise in the form

Given: certain things. Prove: certain things.

We need more emphasis on the fact that we are really proving a sentence of the type: Certain data lead to certain conclusions.

In most instances delinquency is the result of neglect—parental or social—JACOB PANKEN.

COOPERATIVE SCIENCE STUDY AT ARSENAL TECHNICAL HIGH SCHOOL

CHARLOTTE L. GRANT
Arsenal Technical High School, Indianapolis, Indiana

HISTORY OF THE COOPERATIVE SCIENCE STUDY

The Bureau of Educational Research in Science was established in 1935 by a grant from the General Education Board, under the sponsorship of Teachers College, Columbia University. Its purpose was stated as study of the place of science in general education and an attempt to bring science education in schools more closely in touch with the problems of everyday living. During the first five years members of the Bureau concentrated their efforts on preparing materials for teachers, carrying on a number of short teaching experiments using new materials and techniques, and exploring the possibilities of workshops and field contacts as means of inservice education of teachers.

In 1940 it was decided to carry the work further by making a three-year cooperative study of developments in science teaching in selected high schools in various parts of the country. The schools selected were those in which good work in science teaching was already being carried on, and in which the school administrators were interested in encouraging further developments.

One teacher was chosen by the administrator in each school to represent that school, to carry to the Bureau reports of work being done, and to keep members of the school staff in touch with materials and ideas developed by other cooperating schools and by members of the Bureau staff. The representative was to be freed from approximately one-fifth of his regular teaching duties in order to carry on this work. In addition he was to attend summer workshops at which representatives from all of the participating schools would meet to discuss common problems and to make plans for continuation of work in their schools.

Representatives from the cooperating schools met at Columbia University in the summer of 1940 to formulate plans for work in their respective schools. As these plans have been carried out, new courses and revisions of courses have been made. New techniques have been developed and new classroom materials made available. In several schools cooperation has de-

veloped between teachers of the various sciences, or between teachers of science and social studies, or science and English.

The group of cooperating teachers met again in summer workshops during 1941 and 1942. Experiences and problems of the school year were freely shared and discussed. Members of the resident staff assisted in interpreting and evaluating what had been accomplished in the classroom situations. Specialists in various fields of science and in different phases of curriculum development were brought in as consultants. During the 1942 workshop administrators of seven of the cooperating schools joined the teachers for one week.

Reports of the activities and discussions of the 1941, 1942, and 1943 workshops have been prepared and distributed to all of the cooperating schools and to others who are interested in the work of the Bureau. In addition to the Workshop reports yearly reports have been prepared of the work in progress at each of the cooperating schools. Many of these have been issued as mimeographed summaries by the Bureau. During the spring and summer of 1943 accumulative reports were prepared by each cooperating teacher for the school administrator in his school and for the Bureau.

Cooperating Schools

Arsenal Technical High School, Indianapolis, was invited in January, 1940, to become one of the participating schools in the cooperative study with the Bureau. Other schools that cooperated during the three-year period were:

East High School, Des Moines, Iowa
New Trier Township High School, Winnetka, Illinois
George Rogers Clark High School, Hammond, Indiana
Edwin Denby High School, Detroit, Michigan
Cranbrook School for Boys, Bloomfield Hills, Michigan
Cleveland High Schools, Cleveland, Ohio
Cincinnati Schools, Cincinnati, Ohio
Fieldston Ethical Culture School, New York, New York
Bronx High School of Science, New York, New York
Central High School, Trenton, New Jersey
Olney High School, Philadelphia, Pennsylvania

The foregoing were the original schools in 1940; to this number were added:

Oak Park-River Forest Township High School, Oak Park, Illinois
Susan Miller Dorsey High School, Los Angeles, California
Glens Falls High School, Glens Falls, New York
Lincoln School, Teachers College, Columbia University
Colorado State College of Education and High School, Greeley, Colorado

During the period of the three-year cooperative study some thirty-five teachers have participated in the summer science workshops in New York, and have cooperated with the Bureau through use of Bureau materials or through reports of science programs undertaken in their schools.

Integrated courses in science and social science, and science and English, have been developed in Cranbrook School, Denby, Lincoln, Bronx, and Olney high schools.

Other cooperating schools have given emphasis to particular science areas, such as chemistry at Hammond and Oak Park, physics at New Trier and Trenton, and the biological sciences at Fieldston Ethical Culture School and Glens Falls.

In Cleveland and Des Moines, more emphasis was placed on health studies during 1942–43.

Cooperative Science Study at Arsenal Technical High School

In September, 1940, a schedule for active participation in the cooperative study was prepared and circulated among science teachers at Arsenal Technical High School. Four plans—namely, records of classroom techniques and activities, reports on use of Bureau materials, evaluation studies, and cooperation on survey of community resources—were presented. Each interested teacher identified himself with the plan or plans which he wished to follow and develop. The completed schedule carried the names of twenty-three science teachers. During the school year thirteen nonscience teachers were added, as the result of cooperation on the use of Bureau pamphlets, teaching suggestions and evaluation instruments, or in the survey of community resources.

The cooperative science study at Arsenal Technical has included all courses in the science departments. In addition, wherever agriculture, physiology, hygiene, sociology, and astronomy could contribute, that contribution has been sought although these are handled in departments other than the sciences. During 1940–41, development of two new courses, biology and physical science for the slower students, occupied a place of prime importance. These two courses were taught by botany and zoology teachers, and physics and chemistry teachers, respectively. New course outlines and varied techniques were given experimental use. The project method proved one of the most valuable in teaching biology. It was discovered that

several activities for any one science period gave better results with the students whose concentration span was short than continuous experimentation, study, or recitation over a given area. Closer coordination with the needs of the shops appeared desirable in physical science. Classes in botany, zoology, physics, physiography, chemistry, agriculture, physiology, and hygiene were visited by the Arsenal Technical representative, and classroom procedures were discussed with the teachers and summarized for the 1940–41 report to the Bureau of Educational Research in Science. Science Club activities were similarly treated.

The following materials available from the Bureau of Educational Research in Science were used in various classes:

I Source books
- *Life and Environment* (Sears) used in botany
- *Control of Organisms* (Fitzpatrick) used in zoology
- *The Storehouse of Civilization* (Furnas) used in chemistry and physics

II Suggestions for teaching
- *Genetics*—used in biology and zoology, particularly the activities
- *Interrelations of Living Things and Their Environment*—Used in botany, particularly the sections on evaluation and bibliography
- *Materials and Energy*—used in physics
- *Extent of the Universe and Age and Origin of the Earth*—used in astronomy
- *Life Span*—used in physiology and to some extent in biology
- *Vital Statistics*—used in sociology

III Evaluation instruments
- *Your Community*—used in English VIIc and Problems in Democracy classes
- *Opinions on Planning*—used in American government and Problems in Democracy classes
- *Interest Inventory in Materials and Energy*—used in Physics II and Chemistry I classes
- *Interest Inventory in Genetics*—used in Biology II and Zoology I classes
- *Social Distance Scale*—used in Biology II classes
- *Nature of Science and Its Place in Society*—used in Botany II and Zoology II classes
- *Man's Place in the Universe* (pre- and post-tests)—used in astronomy class

In addition to the Bureau instruments, some worthwhile questionnaires, tests, report blanks, interest studies, and check lists were developed by science teachers at Technical and used in their classes. The results of these devices have been analyzed and presented in a more comprehensive report of the three-year study on file with the superintendent of public schools in In-

dianapolis, the principal of Arsenal Technical High School, and Professor S. Ralph Powers of Teachers College, Columbia University. Exhibits, essays, reports on projects and experiments, programs and program participation at school and in the community, interviews, informal discussion with students and parents, hobby and vocational selections also proved valuable techniques of evaluation. Many of these techniques, interestingly enough, could be used as teaching devices as well as techniques for evaluating changes in student knowledge, attitudes, interests, and appreciations after a unit or period of study.

The community survey was divided into fifteen areas, with a committee of Arsenal Technical faculty drawn from science, English, social science, health education, building trades, and the school placement office participating. Library research, interviews, and letter-writing brought forth a wealth of community data. These reports were collected over the three-year period. A summary of the material accompanies the longer three-year report. Certain phases of the material will be found quite applicable and useful in courses of study, particularly in science.

During the fall semester of 1941–42, the representative of the Arsenal Technical High School served as research associate with the Bureau of Educational Research in Science. She prepared three pamphlets on biological subjects during this interval for experimental use in high-school classes. They were entitled *Plant and Animal Communities*, *Forests and Man*, and *Plants and Animals for Daily Use*. Each carried lists of suggested projects to accompany the chapters, and at the end a bibliography of books and magazines closely related to the content of the pamphlet. Maps and tables were used throughout. Pre- and post-tests to determine and to evaluate changes in student-acquired information, student skills, student ability to apply information, student attitudes and interests were prepared to accompany each pamphlet. Report blanks to secure student opinions of pamphlet concepts and ideas as applied to their own communities were sent to each class studying the pamphlets. Eight high schools, including Arsenal Technical, and one elementary school used *Plant and Animal Communities*. The techniques found useful by the various schools in the teaching of that pamphlet have been published in SCHOOL SCIENCE AND MATHEMATICS, Vol. XLIII, May, 1943. A bulletin from the Bureau of Educational Research in Science gave a comparative study of the evaluation results in different schools. An article

giving similar treatment to *Forests and Man*, which was used in the Middle West and East, has been prepared for publication. The third pamphlet, *Plants and Animals for Daily Use*, was used by the author in her botany classes.

During the year 1942–43 changes in curricula and faculty were seen at Arsenal Technical. The impact of the war was felt in Indianapolis as in other communities. The program of courses and activities was directed toward war training and war preparedness. New courses were offered and others were revised to contribute more directly to the war program. Science stepped to the front and took an active part through aeronautics, physics, physiography, chemistry, botany, biology, and zoology. Pre-induction courses as outlined by the War Department in electricity, radio, and machines were offered by the Physics Department for seniors who had not had previous training in these areas. Electricity and mechanics were stressed in the physics classes, and an accelerated course in physics, as outlined by the state committee on physics teaching, was planned for 1943. There were six aeronautics classes taught in the Physics Department, and physiography contributed significantly to pre-induction training. In chemistry special emphasis was given to shortage of certain metals, conservation of strategic materials, defense against bombs and poisonous gases, and chemicals used in the home. Most of the young people taking advanced chemistry planned to go directly into technical war service. More consideration of hydrocarbons and plastics has been planned for 1943–44. Some work on physical fitness and first aid was done in zoology. A new reference book by F. L. Fitzpatrick, *Biology of Flight*, was introduced. More emphasis on ecology and conservation has been planned for 1943–44. Botany and biology have stressed our natural resources, agriculture and gardening, food and nutrition, health and disease, first aid, economic plants and animals, forestry, conservation practices, and vocational development since the outbreak of the war. Various techniques and methods have been used in developing these areas. One of the most interesting is the demonstration Victory Garden plot on the Technical campus. Teaching and evaluation studies have shown that the course outline for biology should be revised in order to adapt the course to the student's daily life, and to bring into the organization more experiments and projects. This has been done for 1943–44. A new textbook, *Biology for Better Living*, by Ernest E. Bayles and R. Will Burnett, recently adopted as

one of three biology textbooks for Indiana, has been selected for use in the course. Revision is also being made in physical science, biology's twin science course of recent origin. Most of the physical science students in 1942–43 were drawn from vocational shops, thus making a more homogeneous grouping. More chemistry is considered for the first semester and more mechanical and applied work for the second semester. Job sheets similar to those used in shop courses may be devised.

Agriculture, although not in the science curriculum, is closely allied to the biological sciences. Food production, farm operation, and gardening were especially emphasized during 1942–43. Conservation of all our natural resources was stressed. A large vegetable garden, including seven varieties of soybeans, was developed on the campus by the class. A Victory Garden show of crops and canned food was given in September. The teacher of this class is also director of gardening throughout Indianapolis. His city school garden course was published in *The Indianapolis News*.

The science clubs, although extracurricular, contributed to the war program of the school. During the second semester of 1942–43 the Nature Study Club undertook a war project sponsored by the U. S. Forest Service. As the result of this participation ten young persons now have the privilege of acting as "junior (U. S. Forest) deputies" in their own communities.

Special studies have been made in science, as well as in fields closely related to science, which have been and will be published. These are described in the longer report on the three-year study. Interesting among these were the Nutrition Program and Victory Lunch Radio Quiz, which were launched in the school at large by the Home Economics Department.

Evaluation of the Three-Year Cooperative Study at Arsenal Technical High School

1. Two new courses, biology and physical science, have developed during the three-year study. These were initiated in response to the needs of a special group, the lower IQ students, of Arsenal Technical Schools. The progress made in teaching these groups has been observed over the three years. Studies on background, training, and interests of these students have been made. New materials and methods for these classes have been and are being de-

veloped. In adapting to the interests and needs of these students, it is possible to eliminate some of the differences which exist between these young people and others of the same age group. The individual teacher is an important factor in the slower classes.

2. Closer cooperation has been developed among departments in the school. Evidence of this is shown in the combined efforts of botany and zoology teachers in the teaching of biology, and of chemistry and physics teachers in the teaching of physical science. For 1943–44, a combined Science-English course has been planned. This course, which will utilize three periods each day, is being taught by a member of the English faculty and the cooperative study representative. Science will serve as the basic material for the teaching.
3. Aids on course revision and course development have been received through summer workshops at Columbia University. This has been especially true in the areas of health, racial studies, and nutrition. New sources of data have been imparted and new materials made available.
4. Specialists in various fields of science and related subjects have assisted in enlarging the scope of knowledge and broadening the outlook of cooperating teachers. Several of these men have been Dr. Sherwood Washburn, of Columbia University Medical School (racial studies), Dr. C. C. Wilson, of Teachers College (on health teaching), Professor Harold Clark, of Teachers College (on community resources and problems), Professor. H. S. Caswell of Teachers College (on curriculum development), and Dr. C. C. Furnas formerly of Yale, now with Curtiss-Wright Corporation (on materials and energy).
5. Closer acquaintanceship with cooperating schools has been achieved as the result of summer workshop participation and winter visitation in the schools. These visits have brought worthwhile contacts, and inspired new ideas and new teaching techniques.
6. Visitation of Arsenal Technical Schools during 1940–43 by resident members of the Bureau of Educational Research in Science has brought the teachers of Arsenal Technical High School into closer acquaintanceship with the work of the Bureau and, consequently, with other cooperating schools, has created an understanding of the

aims and ambitions of the Technical teachers, and has made for general congeniality and fellowship.

7. Yearly reports and special studies have brought together actual accomplishments in the fields of science at Technical, and have clarified thinking on numerous aspects of science teaching. Unusual techniques and materials which, in the opinion of the modest teacher, are not unusual or outstanding enough to proclaim have been uncovered. The Arsenal Technical representative found this to be true in several instances while visiting science classes at Technical.
8. Better knowledge of community resources and problems has been gained through work of and with the committee of Arsenal Technical teachers, and through conferences with individuals actively interested or engaged in city and state planning. The participating teachers, likewise, reported gain in valuable information, and establishment of very worthwhile contacts.
9. Students, through the use of Bureau pamphlets, and particularly by performing suggested projects, have acquired a new knowledge of community resources and services, and an awareness of community problems. Studies of food production and marketing, city sanitation, water supply, and medical laboratories can be cited as examples of such projects.
10. As the result of the many opportunities and experiences of the three-year cooperative study, the representative of Technical High School feels that she is better able to serve the school and the community which it represents.

AIRCRAFT ENGINES MUST BE TESTED IN THE AIR

"Mechanical functioning of the (aircraft) engine can be reasonably well established on the test stand, but installation and flight factors affecting its operation in the air have to be determined in the plane itself," declared L. C. Miller of Wright Aeronautical Corporation, Paterson, N. J. Experimental flight testing at the plant of the manufacturer is advisable, he added.

An engine in a plane is subjected to accelerations in three dimensions of space and in many different attitudes with relation to the force of gravity, he explained. "It is difficult, if not impossible, to simulate altitude temperature and pressure variations on the stand and to evaluate these factors on engine performance."

MOLAL CONSTANTS OF FREEZING POINT AND OF BOILING POINT

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As early as 1771, R. Watson noted that the dissolved substances when dissolved in solvents caused lowering of the freezing point. He held that the degree of lowering was proportional to the concentration of the solution. Not knowing of the work of Watson, C. Blagden in 1788 again stated the same thing as a result of his experiments. In 1861, F. Rudorff repeated it again.

In 1871–72, L. C. Coppet studied the freezing point lowering phenomena caused by solutes. He concluded that equi-molecular amounts of various solutes, when dissolved in like volumes of water, gave the same lowering of the freezing point. He worked with aqueous solutions only, and his results were of limited scope.

The next investigations on this subject were carried out by F. M. Raoult during the period from 1878 to 1886, or just previous to the Arrhenius Ionization Theory. The formulation of what has become known as Raoult's Law appears to date from 1881. Raoult studied solutions of acids, bases, and salts, and he used both aqueous and non-aqueous solutions in his experiments. He measured the vapor pressures of the pure solvents, and the vapor pressures of solutions made by use of those solvents. He made careful measurements of the vapor pressure lowerings caused by the solutes. Raoult found that equi-molecular solutions of different solutes in a given solvent would lower the freezing point of a given solvent by the same amount. The work of Raoult was greatly facilitated in 1888 by the skill of Beckmann who made thermometers of much higher accuracy than had previously been known.

For dilute solutions Raoult concluded that the lowering of vapor pressure caused by solutes is proportional to the number of molecules of solute in a given weight of the solvent. He summed up results as follows.—

$$\text{Depression of vapor pressure} = (\text{Vapor pressure of solvent}) \times \frac{(\text{Number of molecules of solute})}{(\text{No. of molecules of solute} + \text{number of molecules of solvent})}$$

Or,—

$$\frac{\text{Vapor pressure of solution}}{\text{Vapor pressure of solvent}} = \frac{\text{Molecules of solvent}}{\text{Molecules of solute} + \text{Molecules of solvent}}.$$

In terms of weights of solute and solvent, their molecular weights, and of vapor pressures of pure solvent and of the solution, the Law of Raoult may be stated as follows.

$$\frac{p_0 - p}{p_0} = \frac{m/M}{m/M + m_0/M_0}.$$

In this equation we have

m_0 = grams of solvent.
M_0 = molecular weight of solvent.
m = grams of solute.
M = molecular weight of solute.
P_0 = vapor pressure of pure solvent.
p = vapor pressure of the solution.

Evidently, the measurement of molecular weight of a solute might be made from measurements of vapor pressures, but such a procedure would be less convenient than by the use of boiling point data.

The findings of Raoult afforded easy means of determination of molecular weights of dissolved substances by measuring the elevation of boiling point. For one mol of non-electrolyte in 1000 grams of solvent there was found to be constant value of elevation of boiling point, or of lowering of freezing point that was characteristic of that solvent. The work on solutions of electrolytes was to follow the simpler relations that Raoult had established.

For concentrated solutions it was found that the Raoult Law did not hold closely. Such behavior is parallel with the deviations from behavior of the Gas Laws, shown by gases when the latter are under great pressure (concentrated) and at relatively low temperature.

In recent years it has been noted that the relations of freezing point lowerings are not so closely followed in cases where the solvent and solute are of a chemically homologous character. See Chemical Abstracts, 11, 2748 and 14, 1434.

Typical values for the molal freezing point constants and

molal boiling point constants are illustrated by the following table. The values of the constants show slight variations as determined by various investigators.

Solvent	*Freezing Point Constant* K_f	*Solvent*	*Boiling Point Constant* K_b
Acetic acid	3.9 °C.	Acetic acid	3.07°C.
Benzene	5.12°C.	Acetone	1.71°C.
Brombenzene	9.80°C.	Aniline	3.52°C.
Bromoform	14.4 °C.	Benzene	2.53°C.
Cyclohexane	20.0 °C.	Brombenzene	6.26°C.
Diphenyl	8.0 °C.	Camphor	5.95°C.
Formic acid	2.77°C.	Carbon Disulfide	2.34°C.
Naphthalene	6.9 °C.	Chloroform	3.63°C.
Nitrobenzene	8.1 °C.	Ethyl alcohol	1.2 °C.
Water	1.86°C.	Water	0.51°C.
		Phenol	3.56°C.

In the year 1883, the Dutch chemist J. H. Van't Hoff showed that the molal constant for the freezing point lowering might be calculated by use of the gas law constant (R), the latent heat of fusion of the solvent, and the melting point of the latter stated on the Absolute scale. The equation is as follows.

$$K_f=\frac{RT^2}{1000L}$$

$R=1.988$.

T = Absolute melting point of the solvent.

L = latent heat of fusion of one gram of solvent.

Later it was found that the molal elevation of boiling point for a particular solvent might be calculated by the use of the Van't Hoff equation, by putting latent heat of vaporization in place of the latent heat of fusion.

Solvent	K_f *Observed*	K_f *Calculated*	*Solvent*	K_b *Observed*	K_b *Calculated*
Water	1.85°C.	1.86°C.	Water	0.52°C.	0.51°C.
Nitrobenzene	7.07°C.	6.95°C.	Nitrobenzene	5.00°C.	5.27°C.
Acetic acid	3.90°C.	3.88°C.	Acetic acid	3.07°C.	3.14°C.
Benzene	4.90°C.	5.10°C.	Benzene	2.57°C.	2.63°C.
Phenol	7.40°C.	7.60°C.	Phenol	3.60°C.	3.59°C.
Naphthalene	6.94°C.		Naphthalene	5.80°C.	6.35°C.

The close agreement between observed and calculated values for these constants is to be seen from the above table of data.

In concentrated solutions the observed lowerings of freezing point are greater than would be expected from the relations indicated by the Law.

By a study of the results from various solvents a relation known as Trouton's Rule was derived. The Trouton Coefficient,

$$K=\frac{ML_e}{T_0}$$

L_e = latent heat of vaporization of solvent.
M = molecular weight of the solvent.
T_0 = Absolute boiling point of the solvent.

Examples of calculations by Trouton's Rule are as follows.

For water,

$$K=\frac{18\times 539}{373}=26.06$$

For acetone,

$$K=\frac{58\times 124.5}{329}=21.95$$

For chloroform,

$$K=\frac{119.5\times 59}{334}=21.13.$$

For ether,

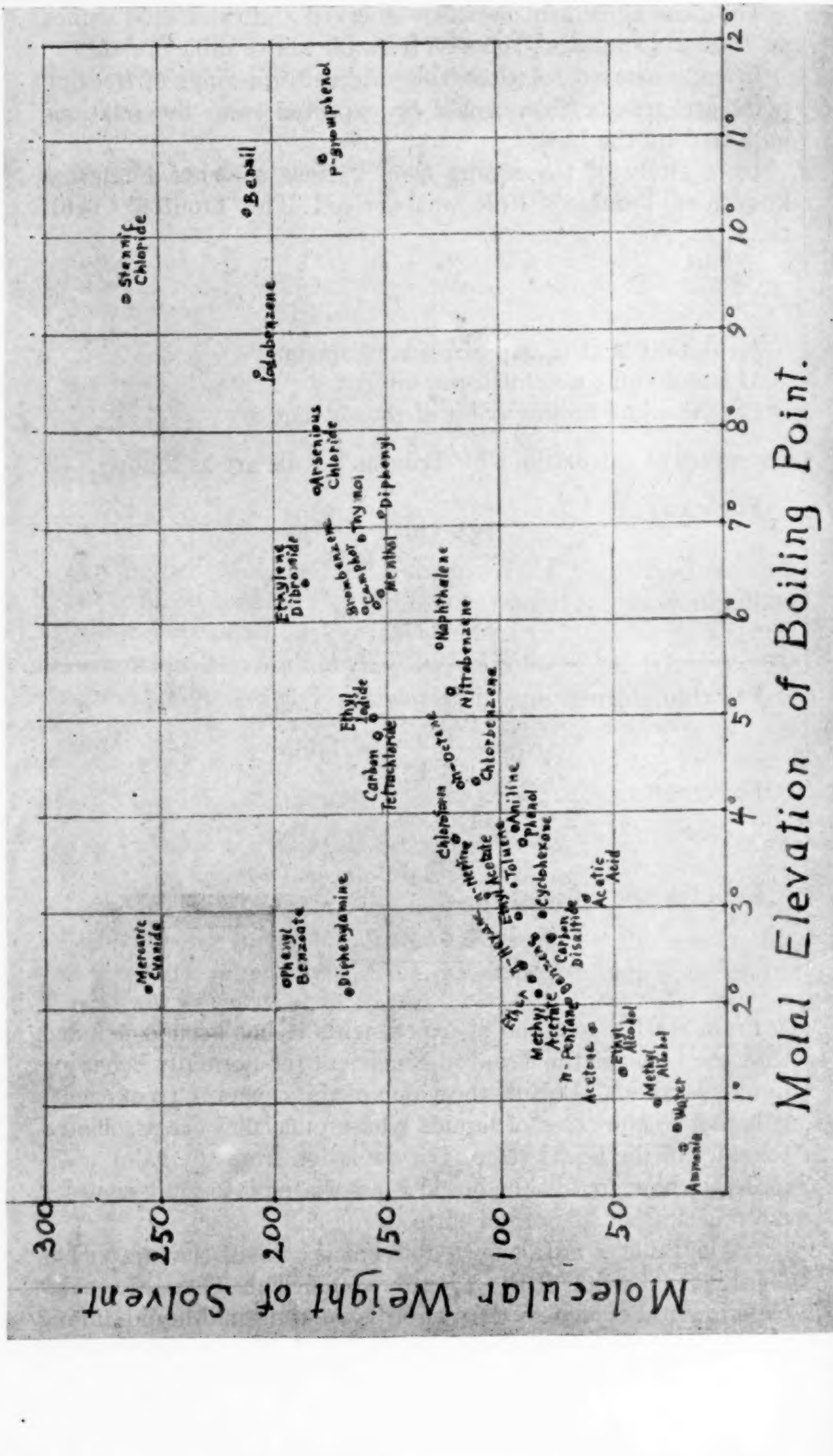
$$K=\frac{74\times 83.9}{308}=20.14$$

For ethylene dibromide,

$$K=\frac{187.9\times 46.2}{405}=21.42$$

From a large number of experiments it has been concluded that the value of the Trouton coefficient for normally behaving liquids is about 21. But, the value of the constant (coefficient) is higher in the cases of liquids whose molecules are associated together in the liquid state. The deviation from the value of 21 indicates how greatly the liquid is associated into more complex molecules, than its normal state.

In the table of data shown above it is evident that water has an abnormal value of the Trouton co-efficient. There are many experimental evidences that water is an abnormal liquid among


Molal Elevation of Boiling Point.
Molecular Weight of Solvent.
300
250
200
150
100
50
1°
2°
3°
4°
5°
6°
7°
8°
9°
10°
11°
12°

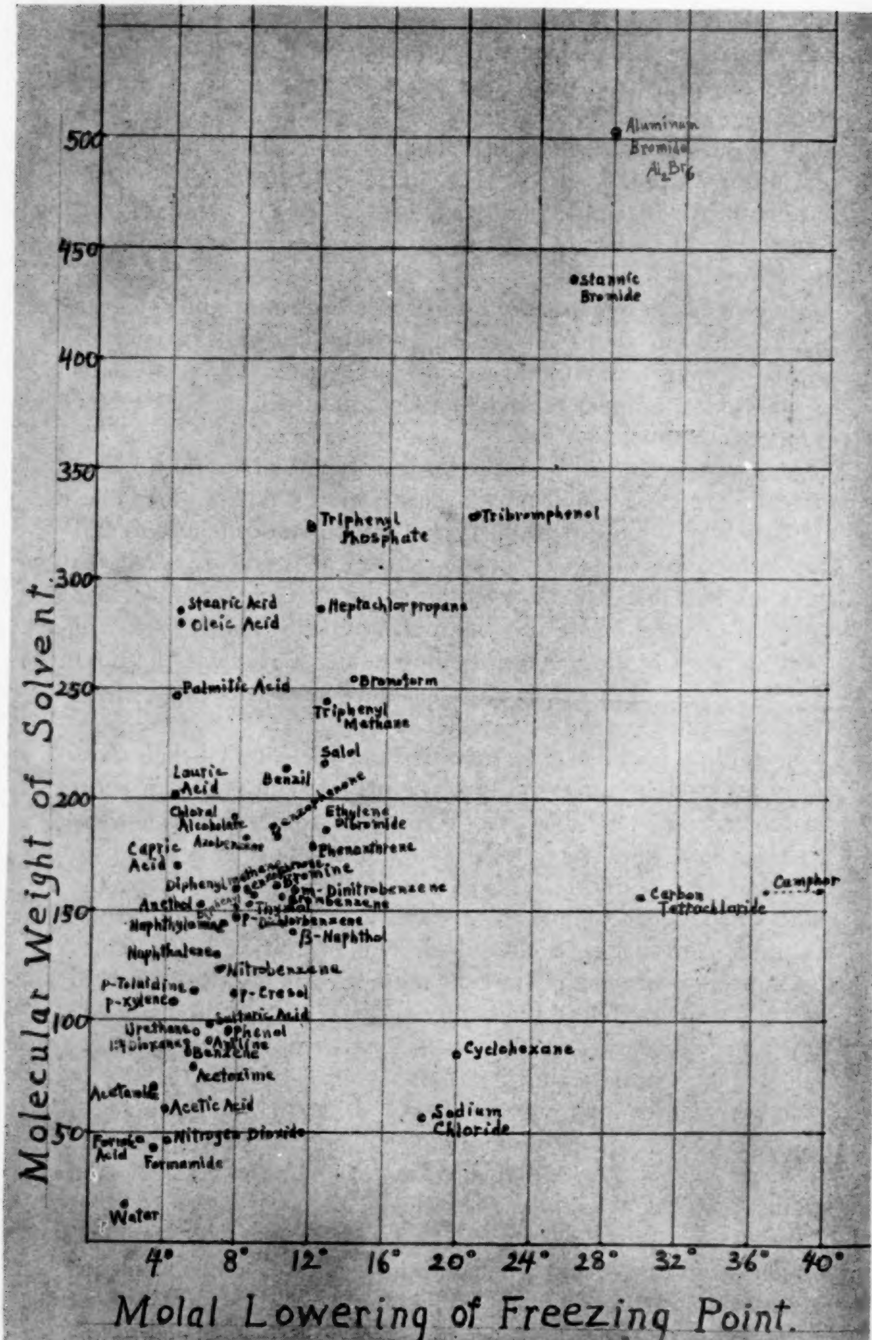
liquids in general. Its maximum density at 4°C., its very high heat capacity, and its value for the rise of liquid in capillary tubes, all go to indicate that water is an associated liquid. X-ray examination of ice trends the same way. Measurements of the viscosity of water tend to show a molecular arrangement of $(H_2O)_6$. Capillary rise is thought to indicate $(H_2O)_4$. Other data indicate the molecular structures of $(H_2O)_2$, and $(H_2O)_3$. For a general review of data as to water, see *Science Progress*, 29, 277 (1934).

In view of the presence of hydrogen atoms of atomic weights 1, 2, and 3, in water molecules, and the known existence of atoms of oxygen of atomic weights other than 16, along with association of simpler molecules it is not surprising that water shows some abnormalities.

An examination of the behavior of solvents other than water in regard to their molal lowerings of freezing points and molal elevations of boiling points led the way to the conclusions and data which are presented below. Chemical literature seems to have ignored relations between molecular weight (or molecular volume) of the solvent and the molal constants for lowering of freezing point or elevation of boiling point. A study of these relations brings out interesting things, and some features for which the reasons are not entirely evident.

In various books of reference there seem to be marked varitions as to the molal freezing point lowering for camphor, bromoform and nitrobenzene. The value for camphor is very high anyhow, and stated values of the constant vary as much as about ten degrees C. There is also disagreement as to the value of the molal boiling point elevation for acetic acid, carbon disulfide, camphor, and chloroform. The variation as to values given in the case of acetic acid may be due to adsorption of water by the acid, or to the tendency for acetic acid to associate to double molecules (double molecular weight) at or near its boiling point. It is claimed also that camphor shows ability to form addition compounds with other substances. The facts alluded to above are made evident by data as plotted on the accompanying figure. Molal elevation of boiling point is plotted against molecular weight of the solvent.

From the figure it is evident that there is a marked general trend for proportionality between molecular weight of solvent and molal elevation of the boiling point. Exceptions are evident in the cases of camphor, mercuric cyanide and various organic


Molecular Weight of Solvent
Molal Lowering of Freezing Point.
500
450
400
350
300
250
200
150
100
50
4°
8°
12°
16°
20°
24°
28°
32°
36°
40°
Aluminum Bromide Al_2Br_6
Stannic Bromide
Triphenyl Phosphate
Tribromphenol
Stearic Acid
Oleic Acid
Heptachlor propane
Palmitic Acid
Bromoform
Triphenyl Methane
Salol
Lauric Acid
Benzil
Benzophenone
Ethylene Dibromide
Chloral Alcoholate
Azobenzene
Phenanthrene
Capric Acid
Bromine
m-Dinitrobenzene
Anethol
Thymol
p-Dichlorbenzene
Naphthylamine
β-Naphthol
Naphthalene
Nitrobenzene
p-Toluidine
p-Xylene
p-Cresol
Phenol
Urethane
Aniline
Benzene
Acetoxime
Cyclohexane
Acetic Acid
Sodium Chloride
Nitrogen Dioxide
Formic Acid
Formamide
Water
Carbon Tetrachloride
Camphor

compounds which are derived from the benzene ring. Mercuric cyanide might be expected to show abnormalities as it is a slightly ionized substance, and is also a salt of a very heavy metal. It will be noted also that numerous benzene derivatives show good proportionality between molecular weight of solvent and molal elevation constants.

Passing next to the figure on which molecular weight of solvent is plotted against molal lowering of the freezing point. Again, numerous compounds show distinct proportionality between molecular weight and molal constant.

However, there are marked exceptions to the above relation. Camphor shows an enormous lowering constant. Values for it given by various authorities differ considerably. Carbon tetrachloride shows great variation from the general behavior, as do sodium chloride, cyclohexane, and chloral alcoholate, heptachlorpropane, and triphenyl phosphate. In the case of aluminum bromide, the general behavior is followed if we use the molecular weight corresponding to the double molecule of the salt.

The case for the fatty acids and their esters deserves special attention. Regardless of their molecular weights, these substances show almost exactly the same value for the molal lowering of the freezing point. The latter value is approximately 4.4°C. for all of them. Association of molecules may account for some of the abnormalities shown by the organic solvents that are listed, and there may be some instances of formation of compounds between solvent and solute which have not been

With Acetic Acid Used as the Solvent		*With Benzene Used as the Solvent*	
Solute	*Molal lowering of freezing point*	*Solute*	*Molal lowering of freezing point*
Methyl iodide	38.8°C.	Methyl iodide	50.4°C.
Carbon disulfide	38.4°C.	Nitrobenzene	48.0°C.
Ether	39.4°C.	Ether	49.7°C.
Acetone	38.1°C.	Ethyl formate	49.3°C.
Potassium acetate	39.0°C.	Acetone	49.3°C.
Hydrochloric acid	17.2°C.	Arsenious chloride	49.3°C.
Sulfuric	18.6°C.	Methyl alcohol	25.3°C.
Magnesium acetate	18.2°C.	Ethyl alcohol	28.2°C.
		Benzoic acid	25.4°C.

recognized. In case the solute is associated, then the mol fraction of the solvent would be larger than is calculated for simple molecules. For associated solvent, the conditions might become more complex.

In the text book on *Physical Chemistry* by H. C. Jones, he calls attention to the trend for molal freezing point lowerings to center around two sets of values, as illustrated by the table on the preceding page.

In regard to the discrepancies shown by camphor as solvent, there are numerous causes and interferences. Various eutectics are formed with camphor. Camphor and naphthalene show an eutectic at 32.8°C. It has also been claimed that the molal freezing point value for solutions of naphthalene in camphor will show variations with changes of concentration.

Camphor is known to form a compound with salicylic acid.

LOOKING AHEAD

For 1944 and the years after educators see such kaleidoscopic developments as "struggle between workers and manager-owner groups for control of the public schools" and "local successes and national failures" in education.

William Dow Boutwell, U. S. Office of Education's Information Chief, sees—

"Another major crossroads for American education. We are moving into a period in which the decisions made will be fully as lasting as the decisions of the '100 days' at the beginning of the New Deal. Then, in the darkness of the depression, education missing the turning, continued straight ahead on its old road while most of our national life shifted into other paths. Although the new crossroads is marked 'Post War' make no mistake for 'post war' will be present in 1944 whether victory is won in that year or not.

"Already more than a million men have been discharged from the service and the question of what education shall do for them is on Congress's doorstep. How shall the post-war Federally-sponsored building program be handled in relation to schools? On what terms shall schools receive surplus war materials? Will we have compulsory military training and, if so, what shall be education's relation to it? Thirty million men and women are coming out of military service and war industries. Who shall retrain them? On what terms?

"These and many other issues will begin to demand answers in 1944. Unless education finds good answers and forcefully and unitedly presses for acceptance of its answers we may again see the Federal Government carrying new educational burdens. Society will tolerate no vacuums. Unless education prepares to fill the post war needs other agencies will. In 1944 education has a rendezvous at a crossroads of history; let education keep that appointment on time, its pockets bulging with shrewd and daring plans for better American tomorrows."

BIOLOGY FOR THE ARMED FORCES*

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A layman who dares to address a group of highly specialized scientists must be keenly conscious of the fact that his observations and comments are general in nature and that he is not equipped with the technical knowledge and scientific nomenclature that are necessary for complete accuracy and for comprehensive treatment. With this understanding I come to you fully realizing that I am making no scientific contribution to your field. If any value may accrue as a result of this presentation, it comes from the "long distance" or "afar-off" view of a worker in the field of secondary education in which it becomes necessary to evaluate the contributions made by each of the fields represented in the curricular and extra-curricular offerings of the high schools.

Pearl Harbor taught us, Americans, many lessons. That fateful stab in the back caused each of us to take stock, compute a trial balance, revise our objectives, re-plan our work, and carefully blue print our newly revised plans. We were shocked out of our normal complacency. In order to get results quickly evolution at various points yielded to revolution. The tempo was set by the military authorities who immediately saw the necessity of mobilizing between 7,000,000 and 11,000,000 armed men. The civil authorities immediately revolutionized industry to supply the needs of America's greatest army. Leaders in the profession of education offered their services and were called to Washington to confer concerning the contributions which they could best make. The value of their services was immediately recognized. The Departments of War and Navy called thousands of our craft into the specialized services of administration, curriculum building, supervision, research, and instruction. Especially in the areas of instruction, curriculum building, and research, the teachers of science have played a most important part. Many of the contributions that the physical sciences have made have been popularized but the equally important contributions of the biological sciences are not so well known especially by the layman.

It is not generally recognized that every physical science situa-

* Paper given before the Biology Section of the Central Association of Science and Mathematics Teachers, Chicago, Ill. Nov. 26, 1943.

tion must have a biological and social science setting. He or they who utilize the results of research in the physical sciences are biological organisms composed of millions of other biological organisms. Further, in warfare as in peace, the acts of each major organism are most significant in terms of their effects upon the other organisms that constitute each particular situation. For example, a soldier must take into account the variable of the individual differences of the different members of his own forces as well as similar differences in the personnel of the enemy. Some of these differences are due to the physical environment, but probably equally important is the physiological heritage plus the former and present botanical and zoological habitats.

What happens to our soldiers when the physical environment changes is of cardinal importance! The extremely low temperatures of the Arctic or the torrid heat of equatorial regions often enormously raised by the engines of tank, ship, or plane, or high humidity expressed by fog, rain, snow or sleet, or a rarified atmosphere affects the actions and reactions of our soldier. His mental attitude conditions his performance as do his food, exercise, and sleep. His ability to distinguish between up-grade and down-grade and to estimate the approximate angle of elevation must be developed highly for scouting and for other specialized military details. His report may be the basis for an attempted bridge head. If the project fails, he may be entirely responsible for the deaths of his comrades; if it succeeds, to him is due the credit. This unique ability is partially biologic and to that extent lies partly within the province of the biology teacher. Other aspects of this biological phase of the human organism, I assume, will be presented by the speakers who follow me on this program.

However, one element may bear some emphasis. It is the national mind or tribal attitude not only of the direct enemy but also of the nations of the lands where our soldier must fight. For example, the attitude of the Hindu towards the "sacred cow" and his belief in reincarnation must necessarily affect the conduct of our soldier should he be in that part of the world where he is associated with the Hindu. The "save-face" attitude is a fixed and integral part of the Oriental mind and our soldiers must know and understand it. Its roots are biological as well as social. Our soldier must understand the origin of the customs of marriage in each area where he operates. D. van der Muelen, former charge d'affaires for the Netherlands at Jidda in an ar-

ticle entitled "Into Burning Hadhramaut"[1] tells of the invitation to this party given by the women of a Bedouin tribe to stay all night and to accept young Bedouin women as wives. An understanding or lack of understanding of how the marriage and other social customs of these peoples were allied to biological principles could have been a matter of life or death for the members of this party.

Two other aspects of the need for an understanding of biology for war are very important. The first of these relates to the preservation of life or of physical fitness and the second deals with the finer appreciation of the beauties of nature.

Let us now examine this first aspect. A soldier's residence changes immediately upon his induction into the army. From those plants and animals in his own locality with which he may or may not be quite familiar he may experience quite a change before he leaves his native land. From the harmless and scanty vegetation of a metropolitan area he may be transported to "boot camp" where the poison ivy, poison sumac, and poisonous mushrooms abound. His susceptibility to the first two plants presents quite a hazard to personal comfort whereas his first contact with the multiple kinds of mushrooms must not be an invitation to smother steaks in them or to use them in his picnic sauce. The animals with which he comes in contact, although usually harmless, may be quite different from those that are a part of his city experience. The ordinary harmless garter snake which he may see once in a lifetime in his city park may be a daily sight in boot camp. But other species also are present and he must not mistake the little copperhead lying behind a rock, which in maneuvers he chooses as a protective barrier, for the innocent little garter snake of his park experience. In desert maneuvers the soldier attempting to use a natural depression for protection might soon discover that it already was inhabited by one or possibly a family of rattlesnakes. Maneuvering soldiers may find not only copperheads and rattlers but also vicious water moccasins inhabiting the hills and creek valleys of one of the big camps in Indiana. In certain sections of the deep South the coral snake and the alligator must be reckoned with under certain circumstances.

Occasional hazards may be found in some species of the large and small game. The grizzly bear, packs of wolves or coyotes,

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[1] *The National Geographic Magazine*, LXII: 397; October, 1932.

members of the various families of "big cats," or Bambi's "flower," may present dangerous or at least disagreeable experiences. The same can be said to a lesser degree of the hornet, yellow jacket, wasp and similar stinging insects. The biting and germ carrying insects likewise are a menace to comfort and at times to health in spite of the almost complete conquest of the diseases carried by them. The realm of microscopic organisms to which the soldier in this country could fall a victim is carefully guarded by the doctors of medicine and their efficient staffs. In spite of this efficient control several diseases defy valid immunization. Syphilis, gonorrhea, tuberculosis, measles, mumps, scarlet fever, colds, influenza, yellow fever, and poliomyelitis are some of the perils with which the soldier may come in contact.

Therefore an understanding of the biological principles underlying one's relations to the plant and animal worlds of our own country and a mastery of certain of the facts connected with each threatening danger are a necessity for the safety and comfort of the American soldier even at home.

A primary function of elementary science, general science, and biology is to give the child a love for the great out-of-doors with its abundance of animal and plant life. In the fields, the woods, the waters, and the air mere weeds, trees, fishes, birds, insects, and microorganisms become lovely friends whose company he enjoys. From the occasional visit made in winter he accelerates his trips as spring advances. He watches the swelling of the buds, the leafing of the shrubs and trees, the return of the birds, and the appearance of the first wild flowers. He knows the habits of the animals and the insects. He can identify most of the native trees and knows something of their lives and uses. On river or lake he knows the denizens of the deep or the shallows. He loves to study the actions and reactions of microscopic plant and animal life. He enjoys the beauties of domestic gardens, both vegetable and flower. He may possess some pets of his own and, if circumstances permit, he will have his own garden. He is interested in conservation activities, especially the preservation of the worthy inhabitants of the air, forest, field, and stream. In these activities he learns to live more fully,—with and in nature and nature's God. Such activities take him into the great out-of-doors, give him exercise and sunshine, and thereby contribute greatly to his physical health. They also contribute enormously to his mental health as he finds rest from the busy

routine of work and has time for the contemplation of such thoughts as "For only God can make a tree."

Obviously then, in camp as well as in civilian life our soldier has a fuller and richer life if he has a sound biological background. Instead of being hopelessly ignorant about the millions of little plant and animal friends and enemies which are ever around him, he knows a great deal about them and spends some of his time with them. His knowledge about and attitudes toward them win the admiration of his fellow soldiers and add to the making of a balanced personality who always has something worth-while to say in any situation to any person or group.

Uusually after the soldier spends a relatively short time in training in one or more centers in the United States, he is sent abroad. There is no formula by which his secondary school teachers can predict the area to which he will be sent. Where he will serve is conditioned by a number of factors which gradually unfold as his military service continues. The army does not have time or staff to give the soldier a thorough training in biology, although it does a pretty good job of preparing him to meet the most dangerous natural hazards of a new area. It may be able to teach him some specific facts but it cannot develop fundamental principles and basic understandings. Yet the army is limited even in this task because it cannot always predict the exact territory where our soldier will serve. For example, one of our greatest athletes, aviator Tom Harmon, was forced down in the equatorial jungles of South America. Bailing out of his plane with little food and water, he had to adapt himself to a new habitat. To be sure there was plenty of the fruit products of the jungle, but which of these should he choose to eat? Certainly some of these must have been palatable and nutritious while perchance others would have produced illness or death. There was "water, water everywhere, but not a drop to drink" in its natural state. For days his neighbors included scores of species of poisonous or dangerous reptiles and insects, wild mammals of varying species and sizes, and strange and often dangerous microorganisms living in a beautiful botanical world. The dead branches lying near a jungle background of orchids are from a strychnine bush. To obtain these branches in order to build a fire to boil some water, our hero must cut and wade through the brush of manchineel trees whose oil glands emit molecules more poisonous than our familiar poison ivy and whose effect was formerly considered to be as deadly as the famous upas trees of

Java. Cutting one's way through the thickets of spiny vegetation, contacts with the Aracomia palm or porcupine tree in the dark torrid jungles probably would be pleasant experiences compared with the horrors of a night relatively unprotected from its nocturnal dangers. At last a trail is reached and footprints are seen. Were they made by an individual who is friendly to the strange white man or could they belong to a cannibal of the Arawaken tribe? The waters of the nearby stream "are infested with the perai, those small voracious fish which," Fairchild says,[2] "hunt in schools and attack and tear to pieces any living warm blooded creature so that one does not usually cool one's body by a dip in the river."

The fundamental principles or understandings necessary to protect life and give relative comfort that confronted our aviator are common to other hot wet areas wherever they are found even though the species of plants and animals largely or completely change. Here is where the work of the biology teacher comes in. He must lay the foundation upon which the army can build a superstructure that is practicable for each theater of war. It must be so well done that the soldier knows that caution is necessary, that he takes no unnecessary risks, that he learns the necessary facts about the plants and animals of his area that he not only will be safe, but also that in that safety he may appreciate to the fullest extent his contacts with them.

This result cannot be accomplished from books alone. The learning of tables of classifications expressed in the parlance of an unknown tongue and the dissection of live animals will not accomplish this end. Such a realization was partly responsible for the substitution of the subject of biology for the subjects of botany and zoology in the high school curriculum. Good teachers more and more have directed the activities of their pupils to observe the operation of the fundamental biological laws and understandings. Facts are used to develop these laws and principles and are observed so far as possible in their natural setting whereas books are used as points of departure and reservoirs of information to aid in developing the larger principles.

This point of view presents other implications relative to the methods of teaching. First, the unit method should be rather

[2] Fairchild, David, "Hunting Useful Plants in The Caribbean" *The National Geographic Magazine* LXVI, 715, December, 1934.

universally substituted for the day to day assignment approach. The unit should rise as frequently as possible from the interests and activities of the class members who should be taught to assist the teacher in setting up immediate objectives, in organizing the attack, and in evaluating the results. To date no single method of procedure is known to be the best, although the various directed study types of activities are generally favored by specialists in education. The Morrisonian plan, The Umstattd procedure, various applications of the so-called contract plan, the project method and other variations lend suggestion which will aid a dynamic teacher in setting up methods and techniques.

Science teachers pioneered in field trips as a technique of teaching. It still needs refinement. Some trips are not well planned and become an "escape from school" valve for the children. Yet, good teachers carefully prepare a background and assiduously plan for each field trip which motivates further study and leads often to one or more follow-up trips by the class and to an enduring interest for many of the pupils. Educational literature suffers from a lack of complete records of such trips, that should detail the major factors from the setting of objectives to the measurement of results. It is the writer's frank opinion that in this way some of our best teaching is done.

The field trip suggests two other variants of the objective approach. The first is the increasing and more efficient use of audio-visual aids. Libraries of such aids now present such a wealth of these materials that a college course dealing with them should be a part of every prospective biology teacher's program. The 16 mm. sound film even in its infancy is revolutionizing our ways of teaching many units. A large number of teachers in normal times supplement the commercial films with those of their own making.

The second objective approach is the vivarium with its pools and bowls of water organisms, its cages of animals and birds, its hives of insects, and its botanical garden with greenhouse where the children may continuously study actual life even though under somewhat artificial conditions.

Biologists may look forward to a greater field through the use of the integrated unit by curriculum makers. Here social science and natural science serve as the springboard from which practically all units originate and in almost all of these biology has a place of cardinal importance. Even more important is the

fact that the biology thus introduced is a living functional science.

John Dewey has ably shown that the best education for tomorrow is a good education for today. Hence, if the future soldier's growth in biological understandings is carefully planned and directed first in his elementary and general science courses and second in his biology and if the school program is so organized and administered that he uses during subsequent years what he has learned, a solid foundation is laid for specific training in biology for the area where he will serve.

The nature of the high school curriculum is such that probably above general science not more than one year can be allotted to biology despite the desire of many scientists and teachers to increase the offering in biology. Demands are coming from all other fields also for an increase in time for them. Obviously the administrator is on the defensive. As a result of very careful consideration of the functioning high school curriculum authorities quite well agree that if the teachers of biology in general accept the point of view of a functional biology, which I am convinced, you progressive teachers already do accept, and address themselves to the real task before them, as your attendance here signifies that you are doing, we will have a biology that is practicable both for the armed forces and also for civilian life.

PENICILLIN PRODUCTION GREATLY EXPANDED

Penicillin, doubled and redoubled, seems to be the American bid for a quick win against infection and disease among our fighting men. So rapidly have production facilities been expanding lately, that a good two-fifths of all the penicillin turned out in this country during 1943 was produced in the single month of December.

Thirteen American and two Canadian firms are now manufacturing the germ-killing drug, and within another five months the list of American firms will have grown to 21, the Office of War Information states.

Quantities of penicillin for civilian use will still be extremely limited, however, for Army and Navy requirements absorb the lion's share of total production, and still more is needed. To stretch the limited supply, the service doctors use penicillin only in cases where the sulfa drugs fail to produce results. If casualty lists go up steeply, even the limited supply now permitted for civilian use may be diverted to the war fronts.

The U. S. Department of Agriculture, whose biologists and chemists have been responsible for many of the improvements in mass-culturing the mold that secretes penicillin, warns against attempts to "produce penicillin in the kitchen." Molds cultured and processed under any but the most critical conditions are very apt to be worthless and may even become dangerous through the growth of "wild" contaminating organisms.

CONSERVATION EDUCATION FOR TEACHERS*
THE OHIO PROGRAM

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"It is strange how fields of study take on importance or not according to our ability to teach them." This is the statement of a ninth grade science teacher in a large metropolitan high school. She had just explained that the conservation unit had been omitted from the biology program for the year because of the lack of time. (Or so the biology teacher thought.)

A few weeks spent in preparing to teach conservation results in changes which will affect in a most vital way the life and teaching of the above teacher. Let us observe some of the reactions as she has expressed them at the close of the Conservation Laboratory 1943 summer program.

Before coming to the Conservation Laboratory at Tar Hollow, she had talked about conservation, read about conservation and heard about conservation, but she lacked a certain something. After a week of experience in conservation living, she began to "catch on" to that certain something—it was a "feeling" for conservation. She was beginning to catch that enthusiasm which is vital to successful teaching. Before leaving the Laboratory, she had written to her principal that conservation is a "way of life"—it is not a body of isolated facts. The Conservation Laboratory had demonstrated to her the possibility of integrating various subject fields into a sound way of life. She returned to her school anxious to spread the "conservation gospel" and alert in planning definite ways in which the idea of conservation would take root in her school this fall. These plans include an analysis of the biology reference materials, at least two teachers' meetings suggested by a cooperative principal and a variety of practical field experiences designed to develop a conservation attitude on the part of the students.

School windows were beginning to open revealing the out-of-doors and with it science began to leap out of textbooks and test tubes and find vitality and meaning leading to a better understanding of our living and the keeping of our democratic way of life.

She now saw that conservation should be taught as a point

* Presented at the Central Association of Science and Mathematics Teachers, November 27, 1943, Chicago, Illinois.

of view and be presented during the entire course—she questioned the advisibility of a conservation unit as a part of the biology program. She now believes that every teacher, in every grade, in every subject has unlimited opportunities to teach conservation. She questioned the advisability of bringing another textbook into an already over-crowded curriculum. She understands why the task of teaching conservation is too vital and too urgent to be assigned to one teacher, but holds that every teacher should feel a responsibility and an interest in this subject.

When we start using the good earth as a textbook, concepts freshen, panoramas lengthen, perspectives deepen, and viewpoints sharpen. Geology becomes more than rocks, soil and water, biology more than plants and animals. For the first time, the out-of-doors means a great deal to the teacher. They have come to realize the interrelationship of plants and animals. Soil is no longer dirt, but a determiner of what will go on above it. Soil becomes our nation's most vital heritage. In the teacher's statement of surprise, she says, "Never before did I appreciate the effect of rocks and soil both past and present on fauna and flora. The ecological approach has been well demonstrated to me for the first time. The simple surveying was a thrill because it was the first time that I had an opportunity to see how mathematics is actually used in field work. Another technique that was interesting to learn was the proper way to trap animals; also how to preserve them."

Ecology had blossomed forth into a realization of relationships that she had never seen before. She was living these relationships. Conservation is the cement which unites these concepts into a picture which no artist can paint—no microscope can penetrate. At the Conservation Laboratory, Mother Nature is the textbook. The text has many chapters. The staff personnel is well selected so that there is a specialist available for each chapter of this most exciting text. After being at the Laboratory for a few days, the teachers are inspired by the work being presented. This inspiration is not just a passing fancy; it is something that grips and grows upon one. This inspiration frequently has been the beginning of a new philosophy of life and living. The world in which we live takes on a new meaning. And so the above teacher reports "The truth is that this course has been so totally different from anything heretofore experienced that it is difficult to evaluate its probable ef-

fect upon my life and teaching. I am inclined to believe that the effect on my personality which will be caught by the students and other friends rather than the facts which will be taught to them will be of most value to all concerned. Surely the thrill of standing on glaciated land after a few minute's ride from the spot which is unglaciated has given me a deeper appreciation of the world about me. The trips to the fire tower fall into the same category. Then, too, never before was I able to grasp so fully the significance of the role played by water. The 'trapped raindrop' story drove the point home. Another highlight was my first walk on the nature trail. Knowing none of the species when I first entered, and then being able to correctly answer most of the questions farther along is something to be remembered. I regret that there wasn't more time spent leisurely on those nature trails. That is one place where a person can't help feeling a deep reverence for God.

"The list of never-to-be-forgotten experiences is endless, so there is no use to try to complete it. Certainly not least of the influences is the outstandingly fine staff. Help of all kinds was always willingly and graciously given. The intense interest caught from all the instructors plus the facts which they teach makes this camp as vital and dynamic as it is. Tar Hollow was and is a fine education!"

Wellington Brink, Editor of *Soil Conservation*, writing in the October issue of his publication describes one phase of the use of the landscape as a textbook as follows: "The plot program at Tar Hollow is illustrative of the teaching methods. Each plot is of two acres; a long, narrow strip hugging a hillside and including both woods and clearings. Two students are assigned to each plot. Their task is an intensive one of research and observation, of measurement and correlation. It poses half a hundred other tasks, the purpose of which is to afford a complete, detailed understanding of the geology and soils of that small segment of the earth's surface, of plant and animal life. Soil profiles are examined and sketched from top to bottom of the slope—leaf litter and humus, depth and texture and colors of topsoil and subsoil and parent soil. Samples are taken of stream and run-off water preceding and following a rain. Channels of air and water drainage are charted. Mineral resources are noted. Past and present land uses are considered. Plants are identified and cataloged and made friends with. A census is made of bird and mammal populations. Insectivorous life is

examined. Miniature nature trails are set up as for a particular school back home. Reports are made detailing similar plot projects to be arranged for other classes of students in other locales. A complete ecological picture is drawn—the relationships of life to life, of natural processes to welfare of man. The whole biota is the challenge. The science branches are bundled up together into the larger and more meaningful science and art of ecology, which controls the compatibility of Man and Nature in companionship and partnership."

The out-of-doors is our classroom. The faculty is selected to represent the four aspects of knowledge having to do most directly with conservation. These are: earth science, botany, zoology, and social science. But instead of the usual separate teaching of these subjects, the interrelationships of each subject to all life is stressed. The students are divided into three groups which are rotated on a bi-weekly schedule to accompany members of the faculty on field trips. During these field trips, the land is still the textbook and the teachers are leather-booted geologists, khaki-clad botanists, ornithologists and soil scientists, who direct the seeing and help shape the deductions.

The pupils in other seasons are teachers themselves. From grade school and from high schools they come, from city, town and rural communities. In their study of Nature's great green book, they now see new and vital meanings in things in their environment. Before, they looked without seeing. Writ on the landscape, the textbook, is that somber wisdom that man must have if he would dwell amiably in his earthly environment. The stated objectives of science teachers becomes a reality. In a recent national survey, out of some 30 suggested objectives, junior high science teachers gave top rating to the following objectives in their respective order:

> To develop a better understanding of the environment.
> To impart knowledge of the environment.
> To develop an appreciation of our environment.

To a conservation teacher these objectives become the core of their program. To most of these teachers, conservation did not convey the same meaning as it does to me. This is indicated by the fact that these teachers listed as the fifteenth item "To foster appreciation for conservation of natural resources."

When one interested in conservation seeks a definition for education, he will find the following most satisfactory. "Education may be defined as that preparation which helps man to

understand his environment and to continue to live in it happily and usefully." This definition is satisfactory when conservation is the core around which the educational program is built. The Conservation Laboratory is pioneering in techniques aimed at a more happy relationship between man and his environment. In the words of Editor Brink, "The State of Ohio is offering to teachers what is perhaps the country's most unique training in natural science. It is unique because it recognizes ecological fundamentals. It is unique because it whets to fine edge the student's capacity to observe, to correlate, and to arrive at deductions. It is unique because it challenges pupil rather than merely pedigogue. All this is a forward step in education. It is a humanizing step. It is a vital and urgent step if the schools of the land are to help insure the future of the land. Teachers come, they learn, they are convinced. And they go back home to teach the little towheads—city and country lads alike—not merely the wonders of the rock or the plant cell or the amoeba, but the wonders and the significance of the earth, of the life it supports and of the hazards it confronts." Soil thus becomes the basis of all life, and water the life-blood of civilization.

Experience is a great teacher. For four years, we have observed the results of the Conservation Laboratory teacher training program. When the teachers have studied and lived these interrelationships, ecology blossoms forth into a realization of relationships which they have never seen before. The landscape becomes a living thing and the teacher returns to his classroom able to see a bit beyond the visible. They have a great intellectual experience and cultivate powers of observation and powers of deduction. If, through this program, only occasionally a teacher catches this enthusiasm which is reported earlier in this article, we might well question its value. The development of these "attitudes" is so apparent that one needs only to visit the Laboratory in operation to go away repeating the words of Dr. J. Russell Smith of Columbia University; "My suggestion is that you go and see the Conservation Laboratory next summer—I think you will be convinced it is something to be introduced in your state."

When we analyze the program and its influence, we will soon discover a shift in the training of these teachers. The teaching of science in this country began with a definite objective, namely that of gaining information. The successful student memorized the facts as presented. This was followed by a period of demon-

stration techniques. At a more recent period, preparation for life as an objective was actually preparation to meet college entrance requirements. At the Laboratory, an effort is made to deal with life's realities. This means that the development of proper attitudes is of equal or greater importance to that of gaining information. We believe that when the stage is set for the development of proper attitudes, that these appreciations and ideals are gained which will motivate a desire for securing the necessary information and these will result in a new and vital purpose perhaps making teaching enjoyable for the first time.

Our teachers gain some enthusiasm and inspiration from the fact that we are pioneering in the development of techniques which may be of significance not only in the teaching of conservation, but to the broader field of general education. This viewpoint has been expressed in the following words by Dr. R. H. Eckelberry for many years Chairman of the Graduate Committee, Department of Education, Ohio State University.

"Much has been said in praise of this as a project in Conservation Education. With this judgement, I am in hearty agreement. But, it seems to me that this project has implications wider than Conservation Education; implications for the whole field of education.

"It seems to me that these things—a cooperative, friendly learning situation; instruction which is functional in terms of life problems; and an experience curriculum—are among the most important things which our forward-looking high schools and colleges are striving to achieve. It is because I believe the Conservation Laboratory is an outstanding demonstration with respect to each of them that I think its activities and achievements should be written up, not only in the literature of Conservation Education, but also in the general education literature."

It is true that we are pioneering, yet a teaching program similar in many respects was established in this country almost three quarters of a century ago. In July 1873, Louis Agassiz established a summer school of natural history on the "Penikese" Island on Buzzards Bay, off the heel of Cape Cod. Years previously, he had told of his hopes for the future of science and methods of teaching it. In those days, science teaching was of inferior order without laboratories and for the most part lacking contact with nature herself. Agassiz believed in going directly to nature—the fountain head for truth. He desired to meet the teachers at the seaside—away from all other influences—go to nature; take the facts into your own hands, look and see for yourself! These were the maxims he preached. Dr. Louis Cornish briefly reports this school in the *Scientific Monthly* for October,

1943, telling how Agassiz was surrounded by 44 students and workmen constructing the building. Everyone was collecting, examining with microscopes, dissecting or watching. They were watching marine animals in aquaria improvised out of pails and buckets. The Library of the University of California at Berkley has a few records of the school. Dr. Cornish quotes from these records; "What a wonderful time we had on Penikese, what a rich experience it was, what a high spot in our lives! Never again shall we have the life!" Such is the tone of the little collection—a precious testimony. The next summer was the second and last session, but without the master, it was not the same school—Agassiz having died in December.

To Agassiz, this was no ordinary school, but a missionary work of highest importance. Dr. Cornish summarizes as follows —"Looking back over the seventy intervening years, we realize that Agassiz started all the summer schools that ever since have flourished independently and in connection with the colleges in all parts of the country. Now it seems likely that for the most part they will become the summer sessions of the universities, a worthy culmination for the notable movement in American education. We realize also that the scientific method taught by Agassiz is now followed in all schools. In his struggle against ignorance and prejudiced conservatism, Agassiz has triumphed."

"Of all sad words of tongue or pen, the saddest are these: It might have been!" These words from the pen of Whittier come to mind as I try to imagine what might have happened had Agassiz lived to firmly establish the out-of-door laboratory for the training of teachers. His interest in nature would undoubtedly have led to an inclusion of the principles of conservation in the schools of America a half a century ago. The waste and destruction which has taken place during this period is beyond the comprehension of the human mind. In soil erosion alone, it is estimated that we are now losing from the fields of America, annually, enough soil and subsoil to fill a freight train long enough to girdle the earth 19 times at the equator!

One purpose in reporting the early efforts of Agassiz is to show that it is to a considerable extent the method used in teaching which is of great importance. The effect upon the teachers attending the Conservation Laboratory seems to be quite similar to those attending Agassiz' Nature School. Space will not permit discussion in detail of additional features of our

program other than naming some of our instructional devices. Some of these are: field trips, nature trail, museum, conservation library, caravan tours, guest speakers, motion pictures, kodachrome slides (teacher units) and lectures by the staff as well as a variety of group discussions.

In this article, little attention has been given to the presentation of conservation concepts and understandings which should be mastered by teachers. In Ohio, we have published a manual *Conservation for Tomorrow's America* which is rich in information and activities. This book is in great demand at this time, requests coming from every part of the nation. Teachers desiring a conservation guide book should examine this and the preceding publication *The Teacher Looks at Conservation.*

The Conservation Laboratory is sponsored jointly by the Ohio Division of Conservation and Natural Resources, the State Department of Education and Ohio State University. The program offers graduate and undergraduate credit—6 to 9 quarter hours. The 1944 Laboratory will begin according to present plans on June 15 and continue until July 21.

Each year as a featured part of the Conservation Laboratory Program we hold a nutrition conference. The theme of this conference is "Our Nation's Health Lies in the Soil." We show how soil deficiencies underlie many of our health problems and thus influence many of our social and economic conditions. The addresses by W. A. Albrecht at this conference indicate the scientific background for an understanding of this most vital of all our national problems.

Excellent work in teacher-training for the improvement of the teaching of conservation is being conducted in many parts of the nation today. Some excellent programs are being offered as campus courses under the leadership of outstanding professors. We trust that the reader will understand that the assignment has been for a presentation of the teacher-training program at the Ohio Conservation Laboratory. In closing, we realize that many questions may remain unanswered. We will appreciate the opportunity to provide any information the reader may desire . . We also have a film entitled "The Teacher Looks at the Conservation Laboratory" which will be of interest to some who care to make a further study. The film is 16 mm. kodachrome and about 800 feet in length.

METHODS AND DEVICES USED IN MY TEACHING AT MONTEFIORE SPECIAL SCHOOL

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Before narrowing down to Methods and Devices employed by one teacher in teaching one subject, it might be well to briefly view the work of the Montefiore Special School as a whole for only in its work as a whole lies the success of the school.

The Montefiore School is designed for boys who need special attention educationally, psychologically and mentally. It is for boys who have fallen behind the grades in which other boys of their age belong. It is for boys who have been unable to get along in the regular schools, for those who need special methods and for those who have interests and aptitudes that need to be developed. Reasons for their unadjustment in the regular schools are many and not necessarily the fault of the school, but whatever the reason, the boys transferred to the Montefiore are boys not wanted elsewhere and sad indeed is the boy who because of social maladjustment knows he is not wanted. It may be his own fault, but yet he may be unable to adjust himself and he always needs special help.

The boys are transferred to the Montefiore School by school transfer and are not committed by Court action as it is the intention to keep the boys out of Court if in any way possible.

Boys are in school at Montefiore for six and a half hours daily, five days a week for forty-eight weeks in the year.

The factors considered in the boy's placement are; educational, mental, social, physical, and chronological ages; aptitudes and interests, disabilities and personality traits. The placement of the boys is made by the school's psychologist in conference with the receiving room teacher and one or both discuss the matter with the boy and his own suggestions are always considered and often tried. The placement is not final, the grading is very elastic and changes are made frequently whenever it seems advisable. The flexibility of the school's curriculum, the absence of a rigid grade placement and the elastic and continuous programming are further evidences of departures from regular school procedures in the care of problem cases.

The boys spend part of their time in academic work in mathematics, reading, English and social studies; part in laboratory

and shop activities of various kinds; and part in organized recreational groups.

The teacher of the Montefiore Special School meets the new pupil entirely cognizant of the fact that he has passed through a period of training under very excellent teachers, who relinquished him to the special school only as a last resort for social reclamation. Nevertheless this problem child feels that he has found but little in the traditional school life to repay him for time spent there. To change this attitude becomes the all-important task of the special school. After spending several days in the Receiving Room this work is well under way by the time the pupil has been placed in his new home room where he soon comes to feel himself an integral part of the group.

The science room operates upon the theory that "nothing succeeds like success." Because of this, the first assignments after the pupil has become oriented, are so definite and simple as to insure visible progress in some direction. This is to be desired because the joy of successful accomplishment is one of the really great factors making for a healthy outlook in life. Then too, the new comer as a rule, is anxious to impress the group with his ability and thus establish his status. One recent example of this was in the case of a boy who entered when the class was studying about coal and the plant and animal life of the Carboniferous period. Upon seeing a picture in his text book depicting an artist's conception of two dinosaurs about to battle, his face lighted up and he came quickly with the request that he be permitted to reproduce the picture in color and greatly enlarged. He proved his ability. His poster was given a prominent place in the room. He may never be an outstanding science pupil but he has definite ability in art and finds that his science presents new outlets in his field of interests.

Another case was a boy, who while being enrolled, centered his attention on a small radiometer near the desk. Very abruptly came his question, "Please ma'am, what makes that go?" It was a bright sunny day so I handed it to him and suggested that he take it over to the window and watch it. He was left there alone while I continued my work. I noticed he was learning "the why," for he would remove it from the sunny window, place it in a dark corner on the floor, observe and repeat. After several such tryouts he returned with—"It's the light that makes it go. Have you got a book that tells about it?" His first sheet of work was a neat little drawing of a radiometer with his story of "his dis-

covery and the why." His experience had been a happy one—he was a success—he was ready for a new attack.

Interesting bits of equipment such as a radiometer, pulse glass, models of engines, models of pumps stood in jars of water, phone dials, thermometers both Fahrenheit and Centrigrade, Bunsen burners, tripods, ringstands, scales, small microscopes, magnets, iron filings, flasks, beakers and countless things are scattered about as interest provokers, to be used as was the radiometer and always with ready reference at hand for follow up study.

Any activity undertaken is purposeful and has a definite objective, yet is sufficiently simple so that the individual engaged in it may reach conclusions which are within the range of his own mental ability.

It is a well known fact that children are not guided by what they know, but rather by their attitudes. Attitudes determine how they approach the business of living and how they will permit life to affect them. We all believe that the business of life is not business, but living, living harmoniously with ourselves and our fellow humans. This development of attitudes then must be a prime objective of our work.

This attitude is quite lacking in the new groups and it requires careful planning and tact to gain results. One device used for this purpose is to set up several simple experiments based on the same scientific principle, as for example—"air expands when heated," and permit a group to investigate and experiment beginning with the simplest and proceeding to the more difficult.

To carry this out there must be careful handling of equipment, freedom of movement about the room, duplication of set ups, close observance of instruction, respect for the rights of others, a willingness to share in responsibility of success or failure, and a sense of duty as to leaving all in readiness for the next group. In this sense scientific education is a means of character building, hence its place of prominence in the special school program.

Naturally, a child's concern is to discover his environment, its nature and its behavior. He has also to discover himself in relation to that environment, its action upon him and his reaction to it. Unfortunately, in many instances, his environment has not been the best, but in the words of the poet,

> "Two men looked out from their prison bars;
> One saw mud—the other stars."

Is it not a part of our work to train the child to see the best in life?

The child's native urge for activity creates its own problems as it acts upon the environment. If the environment is appropriate for this activity, scientific problems are stirred up which challenge a child of average capacity, even if he does occasionally need the help of an adult in their solution.

We as teachers, are prone to fail to recognize the scope or ability of our pupils' interests. We know them only as they appear to us in class. If we would learn more of their outside environments and interests we could be of infinitely more value to them in guiding them.

Your pupil rides along in the street car every day. Does he understand its workings? Do you? Would he be able to explain to you or you to him how the electricity gets into the car to cause it to move?—Not necessary knowledge?—perhaps not—but so little knowledge is necessary if we desire merely to exist. Does he understand how the bridge is raised? how the elevator and the escalator work? Could he operate an elevator in an emergency? He has heard about the subway. Has he ridden in it? Does he know what trains do or do not go through it and something of their stopping places? How long is it or how far below the surface? He knows it began to operate this year. Would he be interested in knowing when and where the elevated road first operated in Chicago? or the surface lines? He has learned in Social Studies about the Locks at Sault St. Marie. Has he been through or been taught about the Locks at the entrance to the Chicago River? Do we as teachers stimulate his interests sufficiently in challenging problems about the city to lead him beyond and away from his neighborhood gang by opening up new avenues of interest?

In dealing with the problem boy it is important to remember that habit formation, social adjustment and child development rather than "teaching science" is the real task. The most important duty is to preserve the child's urge to manipulate and to investigate and to whet his delight in discovery.

If a problem is the child's own problem, which he met by a frank contact with environment, and if he is properly guided in the scientific solution of a series of such problems, an interest in principles will come in due course when the child is ready for them. If, however, the things do not meet the level of his activity urge, he directs his impulses toward the persons of his en-

vironment, thus creating emotional problems. Herein lies the opportunity for the alert teacher to anticipate and provide adequate activities and thereby tide over a danger spot.

This is where the extra curricular activity should enter into the case. If the child is of the type not fitted to carry on some more advanced project he can be interested in care and upkeep of aquariums, carrying on some small animal project, arranging seed germination trays, attending to plant boxes, changing material on bulletin boards—checking supplies and equipment—repairing books, filing, transferring marks and doing various other room duties.

It is quite probable that at some stage of growth every child is curious about some scientific questions. Opportunities to satisfy such spontaneous curiosity and the ability to find answers to these questions are part of the Montefiore's work in science. That which arises from real situations forms the basis of much of our work.

Children are anxious to know the reasons, "the whys." When the individual gains the idea of cause and effect, he is an entirely different individual than one lacking this attitude. One of the most important ways of modifying anybody's behavior is to modify their attitude.

One type of attitude to be developed is examining the world in terms of cause and relationship. Dispelling superstitions, seeking reasons.

Another type of attitude that comes out of the study of science is critical-mindedness; a tendency to examine our own opinions and see if, in spite of our self esteem, those opinions are really based on facts and will hold up scientifically. Still another type of attitude to be developed is open-mindedness, a willingness to take an entirely different view when it is found to be correct.

Science is based on simple basic scientific principles—but it is not merely a collection of facts. It is rather a method of looking at the world, a method of thinking, a method of interpretation. Proper attitudes enable a person put in certain situations to act intelligently because of his attitudes and general procedures. To attain this is one very special aim in science teaching.

A science pupil should be taught to think scientifically. A good thinker is influenced by reason not by a sense appeal. Another essential of science teaching is that a child be trained to

really understand his science, not merely attempt to memorize facts, but to gain the simple ideas and by reflective thinking come to a complete understanding and be capable of self-expression of his knowledge of the subject. The test of the understanding is the reaction of the individual to the facts.

As in no other subject, the business of the science teacher is teaching the pupil how to think. Here lies a challenge to the teacher to be critical of her own method of teaching.

In brief in the teaching there must be:

1. definite objectives
2. organization of material and facts
3. a foundation of basic scientific principles
4. an abundance of concrete material
5. sufficient preparation
6. insight, sympathy, understanding, firmness, resourcefulness, courage, consistency, interest and activity on the part of the teacher.

In addition the teacher should be alert and cheerful, and prepared to swing into full action when the class arrives, and insist that pupils be equally prepared.

As a group these pupils have not been pace-makers in their former classes, instead, many of them are of the shiftless type and need systematic routine. It is well to place responsibility upon them and to impress them from the very beginning that "they are in the army now" so to speak and that each one should endeavor, not only to advance himself, but to make some daily contribution to the class. It is essential for the pupil's mental health that he procure the social respect and approval of his classmates. In order to expand children need to be useful.

If the problem boy is to reap the greatest benefit from his experience in the special school he must not be permitted to have any sense of social inferiority or awareness of rejection that would lead to a more serious maladjustment.

These children will ultimately become either an asset or a liability to society and the period spent in the special school may well prove to be the pivotal point in their lives.

Devices, yes we employ them in endless numbers, always, however, bearing in mind the fact that devices are but a means unto an end and in no way to be viewed as an end unto themselves.

First of all we endeavor to create a science environment in a bright cheery room set up as a well equipped laboratory. The room has a teacher's demonstration table and six large laboratory tables each provided with running water, gas and electricity for pupils use. There is also a large aquarium with running water stocked with bass and gold fish and several small aquariums used for snails, plants, etc. as well as terraria and germinating tables.

The room is supplied with small microscopes for each child and a large microscope for the room. There is a plentiful supply of charts and posters some of which have been purchased, some obtained from commercial concerns and others made by the pupils. We endeavor to maintain growing plants throughout the year and to bring in seasonal materials, such as budding branches, bulbs, and entire plants as well as specimens of animal life. The spring of the year usually brings supplies of fruit tree branches to be forced into early bloom, pussy willows, tadpoles, mud puppies and turtles; the autumn offerings appear as cat tails, leaves, seeds and nuts with a good supply of cocoons which more than repay for the effort spent in gathering them when later the moths emerge in gay spring costumes.

Various projects have been carried on from time to time. One of these was raising guinea pigs—this proved very interesting. At another time we had a colony of moles. We had them in a large glass aquarium with soil 8″ deep. They were very industrious. They made new runways and changed the whole place almost every night. A most prolific project is raising white rats. One of our most successful projects was with silk worms. This project was begun in the fall when we procured the eggs. The tiny worms hatched out in the spring. There were mulberry trees growing in the block so the worms could be fed. They matured, spun their cocoons, emerged, mated and laid eggs which proved fertile. This project carried over for four years.

A large cabinet cares for our collections of petrified wood, rocks, shells, starfish, sponges and other interesting specimens including our common cereals. These specimens are not stored and carefully preserved but instead are passed around and handled by all pupils. To know that sponges attach themselves to some hard substance becomes real knowledge when you handle rocks from Florida's shores with sponges really fastened onto them and when the teacher tells her experiences of going out on the sponge boat at Tarpon Springs and later traveling up

and down through the smelly streets of the sponge market—the world's largest—and passes out the colored post cards showing the Greek ceremony held each year over the sponge fishing waters. This followed by a film on sponge fishing and surely some knowledge on sponges is gained.

Likewise the term, petrified wood, has a real meaning when a child has heard the story, seen the pictures and handled the heavy pieces from the Arizona forests. In like manner when the teacher tells the child that the very cocoanut in his hands was picked up by his teacher under a tree in Florida he gains a new impression of it. Termites too, become more realistic when you have read of them, seen them on the screen and then handle the termite eaten pieces of wood.

An active bulletin board is maintained by combined pupil and teacher participation.

Field Museum Cases on natural history are provided by the Museum and changed twice a month.

Science magazines are subscribed for by the school and used in the classroom work for keeping informed on the latest developments along science lines.

Pamphlets in abundance are supplied on many subjects. These are used either in definite assignments or as free reading. Among these are pamphlets on Conservation of Soil—Forests and Natural Resources, The Story of Light, The History of Salt, X-Rays and Health, Stories of Great Men in Science and many others.

Pamphlets were used in one recent lesson following a film on, The Telephone. The pamphlets were placed in the hands of each pupil on three successive days. The first pamphlet "How to Make Friends by Telephone" was a simply written pamphlet with interesting colored pictures and developed twenty correct procedures to be followed in using the telephone. The last page was a score card for self scoring.

The second pamphlet was a little story—"The Magic of Communication" and dealt with telephone chronology.

The third, a more difficult pamphlet entitled "From the Far Corners of the Earth" dealt with the raw materials used in the telephone—what they are—whence they came and how obtained.

We also have a library of about one hundred science books in addition to the World Book Encyclopedia. Some helpful books for devices:

1. *Gilbert Experimental Glass Blowing for Boys.* Published by A. C. Gilbert Co., New Haven, Conn.
2. *Science Experiments for Elementary Schools,* by Charles K. Arey. Publisher—Bureau of Publications, Teachers College, Columbia University.
3. *Laboratory Experiments in Practical Chemistry,* by Newton H. Black. Publisher—Macmillan Company, New York.
4. *Magic for the Elementary Science Class,* by Martin Gardner, Magician, based on Discovering Our World—Books One, Two and Three, by Beauchamp, Blough and Melrose. Publisher—Scott, Foresman and Company.
5. *Science Experiences With Home Equipment,* by C. J. Lynde. Publisher —International Text Book Company, Scranton, Pa.

Our room is supplied with a stereopticon in which are used mostly pupil made slides for review, drill and test work. We also have a filmo-sound and films are used very successfully as a tool of instruction. The teacher using films should determine previous to the beginning of the semester what films are available and place the order well in advance. The Board of Education has a very complete film library and a regular system is followed in ordering films. Excellent free films are also available from several other sources.

The proper application of the educational film is not difficult. It requires a certain degree of ability in the manipulation of the necessary mechanical devices, and it requires careful planning and the realization that films are teaching tools to use and manipulate in order to gain a predetermined objective.

From the educational standpoint there must be a reason for showing a film; there must be a class preparation; and there must be a completion of the unit.

Pupils in the Science room are trained to operate all machines —stereopticon—silent movie projector and filmo-sound and to check and care for all materials.

In conclusion let us ponder over the fact that the very terror of the present war catastrophe is not the work of ignorant people. It is the work of so-called educated people. All the studies in the laboratories of yesterday, which promised beneficence to mankind are being used to prosecute a war that might have been avoided if leaders had been willing to discuss their problems in the light of reason.

That this blot upon our civilization has serious repercussions in the adolescent group is not to be questioned.

Scarcely can one glance over our current magazines or daily papers but they note some panacea being offered to ally the

alarming wave of juvenile delinquency and check the post war peril of increased delinquency.

As has been truly spoken, "reform schools do not reform, nor penitentiaries make penitent." The individuals in these groups have passed beyond the portals of our schools; they represent the failures of our social, civic and educational institutions, and sad to say, great is their number. The adolescent, the problem child is still in our keeping. Might it not be well to look upon the unrest of our youth as an expression of their unguided effort to adjust themselves to their environment, as they see it, in this chaotic world of today? A world where so many parents have lost sight of their first duty, their home, their family and the rearing of their children. A world in which parents have absented themselves from their communities, their homes and their families in the name of patriotism. These parents do not seem to recognize the fact that the proper parental care of their children is their first and most patriotic duty, for the child of today is the man power of tomorrow.

Preventive medicine is seldom spectacular, but ever and anon, an ounce of prevention has proven to be of greater worth than a pound of cure. It would seem that in view of our past experience and the social problems confronting us it would be more logical in our teaching to stress human personality, human dignity, rights, duties, social solidarity, tolerance and such rather than purely materialistic things.

We as teachers, as educators, as citizens, are in key positions to make our greatest patriotic contribution to our country by acquainting ourselves with the social, moral and educational needs of our communities. It is our privilege to contact and understand the child and his family through our daily work. It is our duty to know and understand our community its advantages and its needs and to work with its civic, social, welfare and religious organizations to bring about a general betterment, and by united effort to develop a program of preventive measures for combatting juvenile delinquency by changed attitudes.

The good education of youth has been esteemed by wise men in all ages as the surest foundation of the happiness both of private families and of commonwealths.—Benjamin Franklin.

THE MATHEMATICS LABORATORY*

MARY A. POTTER
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Mr. Smith, a mathematics teacher, noticed that Harry Jensen was day dreaming, and not following the explanation being presented at the blackboard. To bring Harry back to his lessons, Mr. Smith said sharply, "Board, Harry, board!"

Startled, Harry roused himself and replied, "Yes, sir, very."

And do you always blame him?

Can you see, with the eye of memory, the classroom where you studied mathematics, which may have been like the one in which Harry was sitting? If you can recall it, the chances are that you are picturing a good-sized room, well lighted, with plenty of blackboard space—and those blackboards may have been expensive slate—a few pieces of dirty string for drawing circles, one hand illustrated textbook for each pupil, and one or two fly specked pictures of long dead mathematicians that no flesh-and-blood child of the twentieth century could ever imagine as human beings. The wonder is that a skilful teacher and a willing pupil ever accomplished the act of learning in this environment and with this equipment. It is a matter of record that early discoveries in science were often made by a genius brewing his concoction in crude utensils over a kitchen stove. But it is also a matter of record that with the elaborate scientific equipment of today, ordinarily bright men, who lay no claim to genius, have multiplied discoveries and inventions that have transformed the world. Is it not possible that a mathematics laboratory, replacing the bare classroom of a generation ago, may make for a wider diffusion of mathematical knowledge and accelerate helpful mathematical discoveries?

The Committee of the U. S. Office of Education and the National Council of Teachers of Mathematics investigating Minimum Mathematical Needs for the Army, report that it is common for inductees to know mathematical principles but be unable to apply them. That means that at times we have been able to impart the abstract ideas—a fact which we have sometimes doubted in our moments of self-analysis—but that very often we have assumed that the student was capable of making his own transfer, which he frequently cannot do. Teaching for

* Read before the Junior High School Section of the Central Association of Science and Mathematics Teachers, November 26, 1943.

transfer is an important step in mathematics teaching, especially in dealing with pupils endowed with average or mediocre minds. Perhaps we can make this method of teaching for transfer clearer if we first review the steps in teaching number which are understood by teachers in the elementary schools and are of equal importance to the Junior High School teacher. Suppose we wish to teach the number 5.

The first step is to isolate five objects, which are repeatedly pointed out to the child: five boys, five books, five desks, five chairs. When this step is grasped, the first stage of semi-concrete is introduced. The child is shown many pictures and draws pictures of many groups of 5 concrete objects: 5 pumpkins, 5 dogs, 5 Christmas trees. The second stage of semi-concrete departs still farther from the object and shows the idea of 5 by cards containing 5 crosses, 5 dots, 5 triangles. When this stage is mastered, the child is ready for the abstract number 5, divorced from every object. Farther along in his school career the pupil forgets the concrete background of his abstract number. He learns that $4\times 5=20$, and that abstract fact has to be interpreted and applied to 4 rows of 5 children, 4 times 5 Christmas trees. This is the step required for transfer of training, the important step that we teachers so regularly fail to take. But this step and the original building up of the concept of number are the places where the mathematics *laboratory* in contrast with the mathematics *classroom*, is invaluable.

Part of the effectiveness in using equipment may also be due to the fact that seeing is believing; part to the fact that objects are more interesting to children than abstract ideas and hence are excellent devices for motivation.

Motivation, especially immediate motivation, is a strong weapon. They tell me that in a school for air cadets, if the instructor tells his class that not knowing a certain fact may cost them their lives later on, they are vaguely interested; but, if he tells them that not knowing that fact will cost them their liberty next week end, they respond by working with fury.

To be perfectly honest, did you yourself always like abstract numbers, or are they a cultivated taste made palatable by frequent tasting, careful seasoning, and delectable sauces? Being equally frank, when I went to school I never saw any value in advanced mathematics except as an easy way of piling up credits until I took courses in Physics where it functioned miraculously.

Did you read the article in the October issue of the *Reader's*

Digest entitled "Show-How: A Revolution in Management," which describes present day and efficient teaching of factory employees? The method of teaching—called Job Instruction Training—presents an interesting pattern that we may study with profit. The trainer, who is presenting a lesson to foremen, puts the men at ease and their lesson begins. He attempts to teach a volunteer to tie an underwriter's knot using verbal instruction only; and the volunteer does not learn how to do it; the trainer tries a second time with another volunteer, this time merely showing the process, and the teaching is again unsuccessful. These two demonstrations were made to show usual ineffective ways to teach. The trainer then taught the third volunteer by the effective method. He began by telling the purpose of the knot, then he both tells and shows at the same time how the knot is tied, while the volunteer follows, using his hands as well as his eyes and ears. The knot is quickly mastered.

Miss Jones was convinced that for the sake of Tom, Dick, and Harry, she must convert her classroom into a laboratory, and she has made an amazing transformation. Shall we look and see what she has done?

We find a room planned to be a mathematics laboratory which is not a social science or typing room that happens to be vacant the period at which a mathematics class recites. It has built-in bulletin boards used for mathematics displays; it has show cases, perhaps a table, for exhibiting temporary collections; it has large cupboards and many drawers in which material is stored; it has a graph chart hung where it can be used at a moment's notice; it has a demonstration slide rule; we see a screen which shows that there is a projector available; we feel a mathematical air imparted by the pictures on the walls; and at the front of the room we see a mural which, Miss Jones explains, was made by the mathematics club.

Because they would get dirty otherwise, and because in profusion they are confusing rather than stimulating, Miss Jones keeps most of the models and such materials in her spacious cupboards, taking them out when they are used to illustrate some principle or teach a concept. We have permission to peek into the cupboards and see what they contain.

Miss Jones explains that she has been able to procure some commercial models the price of which was included in the school budget, after she had convinced her principal that such an expenditure was not a waste of school funds.

There were good sized prisms and cylinders, a cube, a sphere, a cone, and 1728 cubic inches that she had persuaded Mr. Matthews of the Industrial Arts Department to cut out for her from some lumber she had bought.

In the next cupboard were various instruments. A transit lent life to the problems of indirect measurement, she said; there were six blackboard rulers, and an equal number of blackboard compasses, a blackboard protractor for geometric construction. A discarded gas meter helped make decimals real. A cardboard clock face aided in teaching time and made angles a part of life instead of mere lines; both centigrade and fahrenheit thermometers were instruments of measure to be taught and were valuable in chcking substitution in a formula. Inexpensive scales for weighing again did a double job of measuring weights and solving equations. Boxes of paper money, like those children get for Christmas gifts, supplied a medium for making change. A set of measures included the pint, quart, peck and bushel. Pointing to measuring spoons and a measuring cup, Miss Jones said, "I wonder how the girls ever follow receipts when they cook, because most of them can't measure ingredients with any degree of accuracy. I have them measure $\frac{3}{4}$ of a cup or $\frac{1}{2}$ of a teaspoon of water until they can do it correctly. That is part of our contribution to good cooking and a happy home."

Exhibiting a carpenter's level and a plumb line, she explained that they were very valuable in convincing pupils that perpendiculars were necessary and should be accurately found.

Rope, a meter stick, and a 50 ft. cotton tape were used in measuring distances.

A third cupboard contained material that the pupils used in seat work. She said that most of the students preferred to have their own rulers, compasses and protractors which they could use at home. But there were sets of scissors provided, various types of squared paper, colored paper, gummed paper both transparent for hinges and colored for making bar graphs, colored wax crayons and chalk, paste, tag board, balsa wood, blank business forms, different sized envelopes for storage, and paper picnic plates.

The next cupboard contained the classroom library. When we commented on the number of books, Miss Jones explained, "The librarian likes to have us take the books, it saves her time and space. The students use them freely here; they love to work the puzzles found in some books, they find harder honor work

in others; they find plays and other material for their club meetings and assemblies, and some years they even publish a mimeographed newspaper or an edition of the regular school paper. You would be surprised to know that the brighter pupils often enjoy reading parts of the teacher's magazines. As for myself, I find I can consult the reference books much more often if they are here; the trip to the library may take more time than I have to spend."

The variety of pictures in the next cupboard and in one file captured our attention. There were moving picture films, film strips, colored slides made from Kodachromes that one of Miss Jones' friends had taken. Besides the tree of knowledge found in most mathematics classrooms, she had posters illustrating the history of mathematics, the airplane with accompanying geometric shapes, posters illustrating the axioms, the uses of mathematics in war, interesting pictures of mathematicians. Both she and her pupils had cut out graphs, pictures, and advertisements from magazines and mounted them for display on the bulletin board. Here also were sheets of tag board on which were mounted samples of cloth, properly labelled, whose patterns were parallel lines, squares, perpendiculars, circles, triangles.

"Would you like to see how we use some of this material?" Miss Jones asked. After we had told her how delighted we would be, she continued, "We have a good bit of trouble in building up a correct mathematical vocabulary. Here are some cross-word puzzles that we use to help fix the words in mind. Then we have posters like this one where the pupils have gathered together all the words that begin with QUAD; on this poster, they have assembled words that begin with TRI. Then we made a loose leaf scrap book in which the children have collected many examples of the use of mathematical words in every day conversation.

"Paper picnic plates look queer for a mathematics classroom, but we have found several uses for them. They make excellent clocks which serve the double purpose of teaching time (for some pupils do come to junior high school who do not know all the niceties of time telling) and they provide the necessity for dividing the circle into six and then twelve equal parts. Then paper plates are a pleasing shape for decorating with designs, when construction is being studied. The pupils like to draw designs, color them, paste a hanger on the back of the plate, and bring them home for Christmas presents. The first time I ever had a

pupil ask me how to find the center of a circle when he knew the arc, was when we were making designs on paper plates.

"It is from this collection of pictures and newspaper clippings that our bulletin board displays are built up. We have five bulletin board committees, each of which takes care of the bulletin board for a week. By having two large moveable pieces of beaver board, one of the committees is always at work on one board while the other board is on display. Preparing these displays makes the students keenly conscious of the mathematics in our daily lives.

"Perhaps the place that we use the equipment most is in the teaching of measurements. Of course, building the concept of any new topic is the hardest phase and perhaps the most important part of teaching the material. For units of length, we cut from rope an inch, a foot, and a yard; we paint them gay colors and have them on display, so that the idea of the lengths will sink in. We use the pupils themselves to make the rod, lining up sixteen in historic fashion and measure the combined lengths of their sixteen right feet. This length is then compared with the length of 16½ standard feet that make a rod, which is also measured off with rope. Of course we do much actual direct measuring with the yard stick, ruler, and meter stick, to fix these lengths in mind.

"For square measure we make square inches out of tag board, and use them in finding the areas of a book or desk. We make a square foot and a square yard out of wrapping paper and more square feet and square yards are drawn on the board which are divided into square inches and square feet. In the hall we usually lay out a square rod—a fairy tale to city children—and then on the school grounds we let the honor students lay out an acre using the rope rod or the fifty foot tape.

"After the pupils have learned square measure they want to find perimeters with square measure. Have you ever noticed that trouble? That's where tooth picks come in handy; they are excellent units of length.

"When the unit of square measure is understood, it is easy enough to teach the areas of different shaped figures, by drawing them on squared paper and counting the unit squares in the figures.

"Volume is more difficult, and that is why I want all these cubic inches. We construct a cubic inch out of paper, and also the cubic foot and the cubic yard, which looks very large to the

children. When the cubic units are well understood, we begin to find volume. The pupils will believe that there are 1728 cubic inches in a cubic foot when they see the immense number of cubes it takes and when they build up the cubic foot themselves. I can teach more about volume in one day with each child equipped with a few cubic inches, than I can in a week without having something for them to look at and handle."

Turning from the cupboards we examined a current display illustrating the hexagon, then being studied by one class. The pupils had brought an amazing variety of things hexagonal in shape—buttons, a plate, a clock, an empty honey can on which a honey comb was printed, a bolt with a hexagonal head.

Near by were several tiny gold, silver, and gay colored solids and plane figures. "What are those for?" we queried and Miss Jones answered our question, "We are beginning to make decorations for the mathematics Christmas tree, our great event. Yes, those handsome colored papers are linings of envelopes and we have kept the designs small because they are more effective trimming. The brightest children make their own patterns but we have many others mimeographed. This is the most painless method we have found for teaching the geometric forms of surfaces and solids, and the mathematically decorated tree is so attractive that it draws an audience including even the parents."

It was with much reluctance mixed with a touch of envy, and with a promise to return to admire the Christmas tree, that we left the charming mathematical laboratory which Miss Jones had so ingeniously equipped.

HEBREW UNIVERSITY IN JERUSALEM HAS SCHOOL OF AGRICULTURE

Despite difficulties due to the war, the first graduating class of students in agronomy will receive their diplomas this year from the recently established School of Agriculture at the Hebrew University here.

The course covers a period of five years. The first two are devoted principally to fundamental sciences like physics, chemistry, biology and meteorology, which are given at the University here. This is followed by one year's practical work on the land. During the final two years, professional subjects such as farm management, plant pathology and animal husbandry are studied at Rehovoth, where a new building has been erected for the school.

The Agricultural Research Station of the Jewish Agency is cooperating with the Hebrew University in carrying out this program, which is under the direction of Prof. I. Elazari Volcani.

A NEW FRONT FOR THE PHYSICS LABORATORY

RICHARD D. SPOHN
Alma College, Alma, California

With no thought of ever writing an article on the subject, but merely to try to focus physics into its proper perspective in relation to life and the general field of a student's education, and thereby to make it more interesting to him, we decided to give the bare walls of our laboratory and lecture room a cultural and professional atmosphere.

That was three years ago. Today, as a result of a little effort and cooperation on the part of the pupils, the Physics Department has earned a reputation and the interest of all who visit it.

As a project for your science club or some of your students you will look far and wide for one that better repays your efforts.

The cost is practically nothing, and gathering the materials, a hobby that any class will enjoy.

PART I

We started with a set of twelve pictures of famous Physicists that we obtained from the Bausch and Lomb Optical Company.[1] These we placed upon the walls of the lecture room.

Between these are some remarkably fine color pictures of The Mt. Palomar Telescope, The Golden Gate Bridge, The China Clipper, a streamlined train, and a huge dynamo, all suitably mounted and lettered by boys with fine artistic talents. These pictures were found on a large calendar.

The lower portion of the side wall contains, in an appropriate location, our bulletin board for assignments and pictures that illustrate applications of the matter covered each day in class.

Nearby is a frame for "The General Electric Photo News"[2] and "The Westinghouse Pictorial Bulletins"[3]—biweekly posters that tell in picture and caption the various scientific and engineering activities of their respective research bureaus.

On the rear wall are to be found the two national charters[4] of "The Bellarmine Physics Academy" and a very neatly executed scroll bearing the following dictum:

> "The titanic forces of nature to a degree have molded man. But, yielding where he must, he has not succumbed. Through his hard-won knowledge of Physics he utilizes the forces of nature to ease his burdens and lighten his labors."

The front wall has, on either side of the main blackboard, a metric chart[5] and a very colorful and symbolic map of the land of Physics.[6] There is, of course, the conventional chart of The Periodic Table of the Elements. Incidentally, this was the sole decoration possessed by the Department when we started our project.

A large chart on the Compound Microscope[7] partly covers a door connecting with the workshop. And, here and there, you will find, among other things, a plaque showing the human eye in cross section,[8] a nicely framed announcement and replica of "The Bausch and Lomb Honorary Science Award,"[9] a portrait of a recent graduate,* who brought honor to his class by winning the "Marconi Memorial Scholarship" in a nationwide competition.

Thus in our lecture room the student is impressed with the dignity of Science and its leaders.

Part II

In the laboratory all apparatus has been arranged in the cabinets, as far as possible, to give the appearance of a display. Everything is kept in perfect accord with the first law of nature: Order. The tables and stools are neatly numbered and painted; equipment for experiments is properly arranged. In such an atmosphere, boys ordinarily inclined to be careless and sloppy soon find themselves victims of a very guilty conscience.

As you enter the laboratory, the first object that meets your eye is another quotation on parchment and framed:

> "Take interest, I implore you, in those sacred dwellings which one designates by the expressive term, 'laboratories.' Demand that they be multiplied, that they be adorned: these are the temples of the future—temples of well-being and of happiness. There it is that humanity grows greater, stronger, better."—Louis Pasteur

Choosing the path of least resistance, it was decided that we would start our decorations of the laboratory with a series of pictures on transportation. A Greyhound Calendar yielded a fine picture, sans advertising, of a modern, deluxe, motor coach, with the skyline of Manhattan for a background.

From the calendar of a cordage company we took an attractive picture of a stately, old square-rigger,—transportation of yesteryear together with an example of component forces in operation.

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* Robert J. Stahl, Class of 1940.

Lockheed Aircraft Corporation[10] sent us some excellent color reproductions of their modern planes.

The father of one boy happened to be vice-president of a leading steamship company. From him we received a large, framed photograph of one of the company's liners.

Another boy was the son of a railroad executive. Through him we obtained a beautifully-framed reproduction of one of America's most luxurious streamlined trains.

By this time, our little project had gained such momentum that we became almost smothered in an avalanche of material. Fortunately, the walls of the laboratory are quite spacious and offer plenty of room for decoration.

The members of the Physics Academy donated a set of fourteen charts on vision, lenses, and color phenomena.[11] These are spirally bound and can be mounted as a unit.

From The Fischer Scientific Company came a laboratory emergency chart,[12] which we mounted near the first aid cabinet.

The General Motors Corporation sent us seven large wall charts,[13] portraying the following in colors:

a) The Automobile Chassis,
b) Engine Efficiency,
c) The Three-Speed Gear Transmission,
d) The Four-Stroke Cycle and Flame Travel,
e) The Diesel Cycle,
f) Automobile Progress,
g) From Iron Ore to a Finished Automobile.

These we distributed about the walls as space and taste directed.

Near that section of cabinets devoted to measuring instruments, hangs a fine color print of an engineer's Transit,[14] graphically depicting a practical application of the units of measure.

A cloud chart[15] covers a large panel of a door leading to the stockroom, and the molding along the top of the blackboard carries a curt little reminder:

"This is a laboratory: with emphasis on the labor, not on the oratory."

Another panel is covered by a rather interesting representation of the dimensions of natural objects in miles.[16] The rear wall above the blackboard furnished space for the five remaining charts, three on electric meters[17] and their working principles, and two on the theory and operation of the storage battery.[18]

Conclusion

The decorations in both lecture room and laboratory are in no way crowded, but placed, each to its best advantage, with the focal point occupied by a very neatly carved crucifix.

All of the work was done outside of class time and volunteers to help were never lacking.

Some of our charts required proper mounting. This was done with lengths of half round molding, purchasable, very cheaply, at any mill.

Our decorations are more than ornamental. For, when necessary, they are brought into the lecture room to be used as actual teaching aids. Students are awakened to an entirely new outlook upon the world in which they live. To them, Physics is not a mass of bone-dry formulae, nor does the demonstration of its principles rely solely upon gadgets that look as though they came from another world.

Sources of Materials

N.B. The writer would indeed be grateful for any suggestions and additions to these sources of materials.

1. Pictures of Galileo, Newton, Fraunhofer, Snell, Huygens, etc. are contained in the free booklet, "Milestones in Optical History," or they can be purchased already framed. For information, write to Bausch and Lomb Optical Company, Rochester, N. Y.
2. "General Electric Photo News"—Free—General Electric Company, 1 River Road, Schenectady, N. Y.
3. "Westinghouse Pictorial Bulletins"—Free—Westinghouse Electric and Manufacturing Company, Pittsburgh, Pa.
4. a) American Institute of Science and Engineering Clubs, New York City.
   b) Science Clubs of America, c/o Science Service, Washington, D. C.
5. "Metric Chart"—Send for Bureau of Standards, Miscellaneous Publication #3 (30¢), c/o Superintendent of Documents, Government Printing Office, Washington, D. C. (N.B. This chart mounted sells for a much higher price at the scientific supply houses.)
6. "Map of Physics"—a very excellent decoration. Unmounted, about $2.00; mounted, $4.00. Central Scientific Supply, Chicago, Ill.
7. "Compound Microscope"—Free. (N.B. Miniatures of this chart, on standard $8\frac{1}{2} \times 11$ binder paper, together with tests on the microscope, are available in quantity. A lecture film and manual on lenses, microscopes, etc. are also free.) Spencer Lens Company, Buffalo, N. Y.
8. "Plaque of Human Eye in Cross Section"—$1.20. Bausch and Lomb Optical Company, Rochester, N. Y.
9. "Bausch and Lomb Honorary Science Award"—Free. Science Award Committee, Bausch and Lomb Optical Company, Rochester, N. Y.
10. Airplane Pictures—Free—Lockheed Aircraft Corporation, Burbank, Calif.
11. Fourteen Charts and book, "Why We See Like Human Beings"—$2.00. Better Vision Institute, New York.

12. Laboratory Emergency Chart—Free—Fischer Scientific Company, Chicago, Ill.
13. General Motors Charts—Free—General Motors Corporation, Detroit, Mich.
14. Engineer's Transit-Chart—Free—Buff and Buff Surveying Insturments, Boston, Mass.
15. Cloud Chart—Free—Send for "Teacher's Materials," U. S. Weather Bureau, Washington, D. C.
16. Chart, "Dimensions of Natural Objects in Miles"—80¢. Central Scientific Company, Chicago, Ill.
17. Electric Meter Charts—Free—(also the booklet, "Electricity"). Weston Electrical Instrument Company, Newark, N. J.
18. Storage Battery Charts—Free—(N.B. Comes as one very large chart that can be quite easily divided.) Electric Storage Battery Company, Philadelphia, Pa.

LEAP YEAR

Every fourth year having an extra day is called Leap Year because during the twelve months following Feb. 29 a date "leaps over" or skips a day of the week, causing dates to fall two days later in the week instead of just one. Whenever the number of the year is divisible by four, with the exception of century years not divisible by 400, an extra day at the end of February is introduced.

The ordinary year of 365 days contains 52 weeks and one day. This extra day causes a particular date to fall one day later in the week than during the previous year. But when there is a leap year, which contains 52 weeks and two days, any date in the twelve months after Feb. 29 falls two days later in the week instead of just one. New Year's day, for example, was on Friday in 1943, and on Saturday in 1944, but in 1945 it will skip Sunday and fall on Monday.

Leap Year was introduced because the earth does not turn on its axis an exact number of times during one entire revolution around the sun. In the Julian calendar, inaugurated by Julius Caesar in 45 B. C., the year was assumed to contain 365¼ days, or 365 days and 6 hours.

The extra hours cannot be included in the year until they have accumulated to a whole day. By the advice of the astronomer Sosigenes, Caesar decreed that the Roman year should consist normally of 365 days, but that every fourth year should contain 366 days.

The true period of the earth's revolution around the sun is 365 days, 6 hours, 9 minutes, 9.5 seconds. This sidereal year is the time taken by the sun to complete the circuit of the heavens from a given star back to the same star.

The year which is used in everyday life, however, is one which depends on the seasons. Because of a slow wobbling motion of the earth called precession, the equinox moves gradually westward and the tropical year, that is, the interval between two successive arrivals of the sun at the vernal equinox, is about 20 minutes shorter than the sidereal year. Its length is 365 days, 5 hours, 48 minutes, 46 seconds. Thus the average year in the Julian calendar was 11 minutes and 14 seconds, or 0.0078 day, too long.

This error of 0.0078 day per year adds up to one day in about 128 years. or causes an error of about three days every 385 years.

WHAT IS A MERIDIAN?

CECIL B. READ
University of Wichita, Wichita, Kansas

Since longitude and related topics may be taught in a spherical trigonometry course as well as in a geography course, it does not seem unusual that a student might discover lack of agreement in certain definitions. In particular, this brought about a consultation of authorities as to the definition of a meridian. If we assume that those authors who refer to "a line on the earth's surface running north and south," or similar statements, have in mind a great circle, we find that all definitions of a meridian are in terms of a great circle. In some cases the term is used explicitly; in others the definition is the equivalent of using a great circle. However, there is a very definite division of authority as to what portion of the great circle constitutes the meridian. That is, many authorities use a definition equivalent to: "a meridian is a great circle passing through the north and south poles"; while another group restrict the definition to a *half* of the great circle.

There are arguments for both points of view, to mention one in favor of the half definition it may be pointed out that when we speak of the *prime meridian*, or of the *38th meridian* we clearly mean half the great circle. Again, although technically we could use the whole great circle and measure east or west from the nearest half, actually we measure longitude from the half of the great circle passing through Greenwich. On the other side it may be pointed out that the half meridian concept causes confusion if we extend the definition to include celestial meridians.

Perhaps the confusion might be removed if we were to agree that a meridian will be any great circle passing through the north and south poles (actually we need to specify only one pole in the definition); but that if we apply a restrictive adjective, such as *prime*, or *45th*, or a qualifying phrase, such as *of Greenwich*, or *of Denver*, this shall restrict our consideration to the *half-meridian*.

A more surprising statement, found in several books, was that meridians are always one degree apart, or to state it another way, are drawn through the points on the equator which divide the earth's circumference into 360 equal parts. If this be true, then apparently there can be no meridian of Wichita. Again, if

a meridian can exist only for whole numbered degrees, what is the meaning of A.M. and P.M. in local time? Perhaps one trained in a special field does not grasp properly concepts in another field. If I am mistaken, I should like to be set right, but it seems to me erroneous to allow only 360 meridians of longitude.

With the present widespread interest in geography, perhaps some teacher of geography can help clear up this concept.

APPROACHING ABSOLUTE ZERO

Notes from an address by Peter Debye, Cornell University

Although the world's low temperature record is now within a thousandth of a degree of the unattainable absolute of cold, there is a good hope that it will be pushed still farther downward, Prof. Peter Debye, Dutch Nobelist in chemistry and professor and chairman of the department of chemistry, at Cornell University, made known in an address before the Pennsylvania State College chapter of the national society of the Sigma Xi, the first of a series of such addresses through the nation.

This will be done by "attacking the disorder hidden in the nucleus of the atom," Prof. Debye said, by use of the magnetic properties of the inner core of the atom instead of the cloud of electrons about it. The influence of a magnetic field upon the spinning electrons made possible the drop in temperature from about a degree to a mere fraction of a degree.

Cooling is explained as an approach to "a state of highest possible order" and at a degree above absolute zero the disorder connected with the motions of the atoms and molecules has been largely removed, Prof. Debye explained. The next step is to bring order within the nucleus of the atom in order to get to an even lower temperature.

The phenomenon of paramagnetism will be used in these experiments, not yet performed, just as it was used in pushing the temperature to its present low level. When a paramagnetic substance, like a piece of soft iron, is demagnetized by taking the magnetic field away from it it absorbs heat. The trick has been to cause it to cool off under these circumstances by preventing it from taking up heat from its surroundings.

This method of getting temperatures lower than are attainable by liquefaction of helium gas was proposed 16 years ago by Prof. Debye, then in Berlin, and Dr. William F. Giauque of the University of California independently, and applied a decade ago in several laboratories here and abroad.

In measuring temperatures just above absolute zero the low temperature gas pressure thermometers used at slightly higher ranges can not be used, but a satisfactory temperature scale can be based on magnetic measurements alone, Prof. Debye explained.

Absolute zero is minus 273.1 degrees Centigrade. Helium, the gas that is hardest to liquefy because its molecules have the smallest mutual attraction, boils at 4.2 degrees above absolute zero and by dropping the pressure to 1/200,000 of an atmosphere, a temperature of seven-tenths of a degree above absolute zero can be obtained. For lower temperatures, the magnetic method must be used.

PROBLEM DEPARTMENT

CONDUCTED BY G. H. JAMISON
State Teachers College, Kirksville, Mo.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.

All readers are invited to propose problems and to solve problems here proposed. Drawings to illustrate the problems should be well done in India ink. Problems and solutions will be credited to their authors. Each solution or proposed problem sent to the Editor should have the author's name introducing the problem or solution *as on the following pages.*

The editor of the department desires to serve its readers by making it interesting and helpful to them. Address suggestions and problems to G. H. Jamison, State Teachers College, Kirksville, Missouri.

SOLUTIONS AND PROBLEMS

Note. Persons sending in solutions and submitting problems for solutions should observe the following instructions.

1. Drawings in India ink should be on a separate page from the solution.

2. Give the solution to the problem which you propose if you have one and also the source and any known references to it.

3. In general when several solutions are correct, the one submitted in the best form will be used.

LATE SOLUTIONS

1850. *Belle Brokaw, Lancaster, Pa.; Emma Williams, Flatbush, N. Y.; Walter R. Warne, Fayette, Mo.*

1849. *Ralph O. Carruth, Clayton, Mo.*

1853. *Helen M. Scott, Baltimore, Md.*

1855. *Proposed by Hugo Brandt, Chicago, Ill.*

Solve for x: $14(\sin \frac{1}{4} \text{ arc} \sin x + \cos \frac{1}{4} \text{ arc} \cos x) = 15$.

Solution by Helen M. Scott, Baltimore, Md.

Let $\phi = \sin^{-1} x$. Then $90 - \phi = \cos^{-1} x$.

$$\sin \tfrac{1}{4}\phi + \cos \tfrac{1}{4}\phi = \frac{15}{14}$$

$$\sin^2 \tfrac{1}{4}\phi + 2 \sin \tfrac{1}{4}\phi \cos \tfrac{1}{4}\phi + \cos^2 \tfrac{1}{4}\phi = \frac{225}{196}$$

$$2 \sin \tfrac{1}{4}\phi \cos \tfrac{1}{4}\phi = \frac{225}{196} - 1$$

$$\sin \tfrac{1}{2}\phi = \frac{29}{196}$$

$$\frac{\phi}{2} = 8^\circ \; 30' \; 31.''24$$

$$\phi = 17 \quad 1 \quad 2.48$$

$$\sin\frac{\phi}{4}=0.074184$$

$$\cos\frac{\phi}{4}=\frac{0.997245}{1.071429}$$

$$\frac{15}{14}=1.071428$$

Solutions were also offered by A. E. Gault, Peoria, Ill. and the proposer.

1856. *Proposed by Nellie Shepson, Elmira, N. Y.*

Solve completely the system:

$$(x+y)(x^2+y^2)=\frac{40}{3}xy$$

$$(x^2+y^2)(x^4-y^4)=\frac{800}{9}x^2y^2$$

Solution by Hugo Brandt, Chicago

$$(x+y)(x^2+y^2)=\frac{40}{3}xy \tag{1}$$

$$(x^2+y^2)(x^4-y^4)=\frac{800}{9}x^2y^2. \tag{2}$$

Divide (2) by (1):

$$(x^2+y^2)(x-y)=\frac{20}{3}xy. \tag{3}$$

Divide (1) by (3)

$$x+y=2(x-y) \qquad x=3y \tag{4}$$

Introduce (4) in (1):

$$4y\cdot 10y^2=40y^2 \qquad y=0 \quad x=0$$

$$y=1 \quad x=3$$

[Introduce (4) in (2):

$$10y^2\cdot 80y^4=800y^4 \text{ yields also } y^2=1$$

but $y=-1$ doesn't satisfy (1).]

Hence the complete solution is (0, 0), (3, 1).

Solutions were also offered by Walter R. Warne, Fayette, Mo.; Margaret Joseph, Milwaukee, Wis.; Helen M. Scott, Baltimore, Md.; Morris I. Chernofsky, New York City; Marcellus M. Dreiling, Collegeville, Ind.; and the proposer.

1857. *Proposed by Grace Ausley, Clifton Springs, N. Y.*

Prove:

$$\tfrac{3}{2}(\sqrt{3}+1)^2-2(\sqrt{2}+1)^2=\sqrt{59-24\sqrt{6}}$$

Solution by Julius S. Miller, New Orleans, La.

(1) Expanding the left side, and collecting terms, we have $3\sqrt{3}-4\sqrt{2}=\sqrt{59-24\sqrt{6}}$. Now square both members.

Solutions were also offered by Gordon Duvall, Cincinnati, Ohio; Walter R. Warne, Fayette, Mo.; V. P. Krause, Austin, Tex.; R. Mansfield, Chicago; Margaret Joseph, Milwaukee, Wis.; Gene Clark, Worland, Wyo.; Wm. A. Richards, Berwyn, Ill.; L. E. Overman, Hammond, Ind.; Helen M. Scott, Baltimore, Md.; Milton Schiffenbauer, New York City; Morris I. Chernofsky, New York City; A. E. Gault, Peoria, Ill.; Hugo Brandt, Chicago.

1858. *Proposed by Hugo Brandt, Chicago, Ill.*

Solve for x:

$$e^{-x}=\sinh(x)$$

Solution by Aaron Buchman, Buffalo, N. Y.

Since

$$\sinh(x)=\frac{e^x-e^{-x}}{2},$$

the given equation becomes,

$$e^{-x}=\frac{e^x-e^{-x}}{2},$$

which upon solving for x, gives

$$x=\log(\sqrt{3}).$$

In the complex field, the logarithm of any number has an infinite number of values differing by integral multiples of $2\pi i$. Thus the general solution is: $x=\log(\sqrt{3})+2n\pi i$, where $\log(\sqrt{3})$ is the real root and n is any integer, positive or negative. Thus the given equation has *one* real root and an *infinite number* of complex roots.

Solutions were also offered by W. A. Richards, Berwyn, Ill.; Hugo Brandt, Chicago; R. Mansfield, Chicago; A. E. Gault, Peoria, Ill.; Morris I. Chernofsky, New York City; Milton Schiffenbauer, New York City.

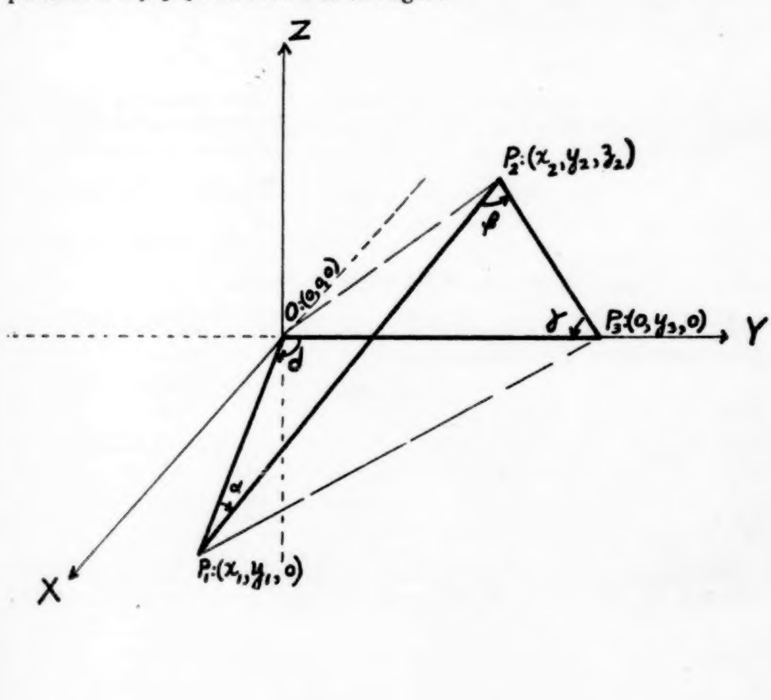
1859. *Proposed by Howard D. Grossman, New York City.*

Is there a formula for the sum of the angles of a skew quadrilateral?

Solution by William A. Richards, Berwyn, Illinois

Yes, there is a formula for the sum of the angles of a skew quadrilateral. That is, we may develop such a formula.

Without loss of generality, we may assume the quadrilateral to take the position $O\ P_1P_2P_3O$ as shown in the figure.



The coordinates are shown in the figure and also the angles. And let $OP_1=l_1$, $P_1P_2=l_2$, $P_2P_3=l_3$, $P_3O=l_4$, $P_2O=a$, and $P_1P_3=b$. Now, from analytic geometry,

$$l_1=\sqrt{x_1^2+y_1^2},\quad l_2=\sqrt{(x_2-x_1)^2+(y_2-y_1)^2+z_2^2},\quad l_3=\sqrt{x_2^2+(y_2-y_3)^2+z^2},\quad \text{and}\quad l_4=y_3.$$

And from trigonometry,

$$r_1=\sqrt{\frac{(s_1-l_1)(s_1-l_2)(s_1-a)}{s_1}},\qquad r_2=\sqrt{\frac{(s_2-l_2)(s\ -l_3)(s_2-b)}{s_2}}$$

$$r_3=\sqrt{\frac{(s_3-l_3)(s_3-l_4)(s_3-a)}{s_3}},\qquad r_4=\sqrt{\frac{(s_4-l_1)(s_4-l_4)(s_4-b)}{s_4}}$$

where $s_1=\frac{1}{2}(l_1+l_2+a)$, $s_2=\frac{1}{2}(l_2+l_3+b)$, $s_3=\frac{1}{2}(l_3+l_4+a)$, and $s_4=\frac{1}{2}(l_1+l_4+b)$; and where r_1, r_2, r_3, and r_4 are the radii of the inscribed circles in the triangles OP_1P_2, $P_1P_2P_3$, P_2OP_3, and P_3OP_1 respectively.

Also from trigonometry,

$$\tan\alpha=\frac{r_1}{s_1-a},\quad \tan\beta=\frac{r_2}{s_2-b},\quad \tan\gamma=\frac{r_3}{s_3-a},\quad \text{and}\quad \tan\delta=\frac{r_4}{s_4-b}.$$

Therefore, the formula for the sum of the angles of a skew quadrilateral is

$$\text{Sum}=\alpha+\beta+\gamma+\delta=\arctan\frac{r_1}{s_1-a}+\arctan\frac{r_2}{s_2-b}+\arctan\frac{r_3}{s_3-a}+\arctan\frac{r_4}{s_4-b}.$$

Hugo Brandt, Chicago and the proposer also made contributions to the solution of this problem.

1860. *Proposed by Helen M. Scott, Baltimore, Md.*

Four equal tangent spheres of radius, r, are circumscribed by a sphere of radius, R. Find R in terms of r.

Solution by Aaron Buchman, Buffalo, N. Y.

Since the four equal spheres are tangent to each other, the centers of the spheres must lie on the vertices of a regular tetrahedron with edges $=2r$.

Now the altitude of a regular tetrahedron is given by the formula,

$$h=\frac{e\sqrt{6}}{3}.$$

Thus $$h=\frac{2r\sqrt{6}}{3} \text{ in the above tetrahedron.}$$

But the altitudes of a regular tetrahedron meet at a point whose distance from each vertex is $\frac{3}{4}$ of the altitude.

Thus $$D=\frac{r\sqrt{6}}{2}.$$

But $$R=D+r.$$

Thus $$R=\frac{r(2+\sqrt{6})}{2}.$$

Solutions were also offered by Hugo Brandt, Chicago; Wm. A. Richards, Berwyn, Ill.; Milton Schiffenbauer, New York City; Morris I. Chernofsky,

New York City; W. R. Smith, Gainesville, Fla.; A. E. Gault, Peoria, Ill.; Helen M. Scott, Baltimore, Md.

A few incorrect solutions were offered.

HIGH SCHOOL HONOR ROLL

The Editor will be very happy to make special mention of high school classes, clubs, or individual students who offer solutions to problems submitted in this department. Teachers are urged to report to the Editor such solutions.

Editor's Note: For a time each high school contributor will receive a copy of the magazine in which the student's name appears.

For this issue the Honor Roll appears below.

1852. Werner B. Teutsch, Philadelphia.

1856, 7. Donna Spelle, Covington, Ky.; Osias Bain, and Wallace Beardsell, Quebec, P. Q.

1857. Robert Obeler, Chicago; Molly Jean Wilson and Erma K. Sanders, Reed Springs, Mo.; Jean C. Vehr, Covington, Ky.; Audrey E. Reid, Convent Station, New Jersey; Helen Bouser, Concord, Mass.; Aubrey Altshuller, Hammond, Ind.

PROBLEMS FOR SOLUTION

1873. *Proposed by Lillian A. MacDonald, Newark, N. J.*

Five times the sum of the ninth powers of the first n consecutive integers is exactly divisible by the sum of the cubes of those numbers and the quotient cannot be a prime number.

1874. *Proposed by Erma Johnson, Lewis, Pennsylvania.*

Solve for B and x

$$\frac{\sin B}{9}=\frac{\sin 2B}{15}=\frac{\sin 3B}{x}.$$

1875. *Proposed by H. D. Grossman, New York City.*

Construct a triangle, given the altitude, the median, and the angle bisector to one of the sides.

1876. *Proposed by W. R. Warne, Fayette, Missouri.*

Find the condition that the sum of two roots of $x^4+px^3+qx^2+rx+s=0$, shall be the sum of the other two roots.

1877. *Proposed by William Meddick, Los Angeles, California.*

Find the condition that all the roots of $x^4-14x^2+24x=K$, shall be real.

1878. *Proposed by Phillip S. Perkins, Camden, N. J.*

Prove that $7^{2n}-48n-1$ is divisible by 2304.

STANDARD SPECIFICATIONS FOR LEATHER PROTECTIVE OCCUPATIONAL CLOTHING

Standard specifications for leather aprons, leather cape sleeves, and leather knee-length leggings, have been approved by the American Standards Association here and are available to those interested. They are the first three in a series of war standards for protective occupational clothing for factory and other industrial workers.

BOOKS AND PAMPHLETS RECEIVED

AN INTRODUCTION TO NAVIGATION AND NAUTICAL ASTRONOMY, by William George Shute, William Wright Shirk, George Forbes Porter, and Courtenay Hemenway, *Instructors in Mathematics and Navigation, The Choate School.* Cloth. Pages xiv+457. 14×21 cm. 1944. The Macmillan Company, 60 Fifth Avenue, New York, N. Y. Price $4.50.

DYNAMICAL ANALOGIES, by Harry F. Olson, E.E., Ph.D., *Acoustical Research Director, RCA Laboratories, Princeton, New Jersey.* Cloth. Pages xi+196. 13.5×21.5 cm. 1943. D. Van Nostrand Company, Inc., 250 Fourth Avenue, New York, N. Y.

BASIC MATHEMATICS FOR WAR AND INDUSTRY, by Paul H. Daus, *Professor of Mathematics, University of California, Los Angeles;* John M. Gleason, *Assistant Professor of Mathematics, San Diego State College, San Diego;* and William M. Whyburn, *Professor of Mathematics and Educational Supervisor, ESMWT, University of California, Los Angeles.* Cloth. Pages xi+277. 13.5×21.5 cm. 1944. The Macmillan Company, 60 Fifth Avenue, New York, N. Y. Price $2.00.

ANALYTIC GEOMETRY, by K. B. Patterson and A. O. Hickson, *Duke University.* Cloth. Pages x+187. 13×20 cm. 1944. F. S. Crofts and Company, 101 Fifth Avenue, New York, N. Y. Price $2.10.

MAN IN THE AIR, by Herbert S. Zim. Cloth. Pages x+332. 13.5×20.5 cm. 1943. Harcourt, Brace and Company, 383 Madison Avenue, New York, N. Y. Price $3.00.

EXPLORING BIOLOGY WORKBOOK, by Ella Thea Smith and Lynda M. Weber. Paper. Pages vi+154. 19.5×27 cm. 1944. Harcourt, Brace and Company, Inc., 383 Madison Avenue, New York, N. Y. Price $1.00.

VITALIZED FUNDAMENTALS OF MACHINES (IN GRAPHICOLOR), by Robert H. Carleton, *Head of Department of Science, Summit High School, Summit, New Jersey.* Paper. Pages vi+186. 12.5×19 cm. 1944. College Entrance Book Company, 104 Fifth Avenue, New York, N. Y. Price 60 cents less 25% to schools.

VITALIZED FUNDAMENTALS OF ELECTRICITY (IN GRAPHICOLOR), by Robert H. Carleton, *Head of Department of Science, Summit High School, Summit, New Jersey.* Paper. Pages viii+184. 12.5×19 cm. 1944. College Entrance Book Company, 104 Fifth Avenue, New York, N. Y. Price 60 cents less 25% to schools.

EIGHTH ANNUAL REPORT OF HUNTINGTON COLLEGE BOTANICAL GARDEN AND ARBORETUM. Fred A. Loew, *Director, Head of the Department of Biology Huntington College, Huntington, Indiana.* Paper. 45 pages. 13.5×21.5 cm. 1943.

AIRPLANE POWER, published by General Motors. Revised Edition. Paper. 80 pages. 13×21 cm. 1943. General Motors, Detroit, Mich. Free Copies.

THE TEACHER OF MATHEMATICS AND THE WAR SAVINGS PROGRAM. Prepared by Walter W. Hart, Veryl Schult, and Violet Coldren with Members of the War Finance Division. Paper. 38 pages. 15×23 cm. Published by the Education Section of the War Finance Division, U. S. Treasury Department, Washington 25, D. C.

BOOK REVIEWS

GALAXIES, by Harlow Shapley, *Director of the Harvard College Observatory.* Cloth. Pages vii+229. 14×21.5 cm. 1943. The Blakiston Company, 1012 Walnut Street, Philadelphia, Pa. Price $2.50.

This is the sixth of the Harvard Books on Astronomy written to give the ordinary student of science an insight into the astronomical world, to point out some of the intricate problems, the steps that have been taken in their solution, and the unlimited study for the future. The book starts with a very brief historical sketch of the progress of astronomical knowledge, gives a short series of definitions used in the later chapters, sketches briefly the methods of measurement, and describes the types of galaxies now recognized. The discussion of the Star Clouds of Magellan in the second chapter gives us a view of a nearby galaxy or of neighboring galaxies. Chapter 3, The Astronomical Toolhouse, requires more careful reading and some serious study if the untrained mind is to grasp its full meaning. Then follows an interesting description of the Milky Way and of the Neighboring Galaxies—those included in a sphere of only a million light years in radius. The Metagalaxy, the subject of the sixth chapter, will again require study for the average reader, but it is well worth the effort. The book closes with a short but very interesting chapter on The Expanding Universe, and leaves the reader with the startling mass of unsolved problems before him. This book is the best of the series and is a credit to any scientific library.

G. W. W.

MODERN CHEMISTRY, by Charles E. Dull, *Head of Science Department, West Side High School, and Supervisor of Science for the Junior and Senior High Schools, Newark, New Jersey.* Cloth. Pages xi+604+xxiv. 15×23.5 cm. 1942. Henry Holt and Company, Inc., 257 Fourth Avenue, New York, N. Y. Price $2.00.

The outstanding features of this book are the following: (1) The two column format. The advantage of this is the short-eye span which promotes ease of reading. This arrangement gives more space for larger drawings. (2) Allowance for pupil differences. The book is divided into units. Each unit is made up of chapters. At the end of each chapter there are questions and problems divided into "A" and "B" groups.

There are previews for each unit. In each preview there are photographs of men of science and a brief biography of each man. Most of the men in each preview have discovered some of the processes which are discussed in the unit. Challenging questions introduce each chapter. There are vocabularies at the beginning of each chapter. Chemically theory is developed logically, clearly, and simply. The latest developments in chemistry are discussed. This includes information on plastics. The strategic use of materials is stressed. The illustrations are excellent, numerous, and functional.

E. G. M.

ESSENTIALS OF PLANE AND SPHERICAL TRIGONOMETRY WITH TABLES, by Clifford Bell and Tracy Y. Thomas, both of the *University of California, Los Angeles.* Cloth. Pages vi+166+142. 14×21 cm. 1943. Henry Holt and Company, New York, N. Y. Price $1.80.

The first three pages of this text introduces the student to positive and negative angles, and to the measurement of angles in degrees, mils, and radians. The first chapter also includes definitions of the functions of the general angle, values of the functions of special angles, variation of the functions, line representation, and graphs. This is followed by the trigo-

nometry of the right triangle, including solutions by logarithms and by circular and straight slide rules. Then comes a brief study of formulas and identities. One short chapter is devoted to inverse functions and equations. The usual formulas for the solution of oblique triangles are given and their uses demonstrated. Many sample solutions are given. In these solutions much attention is given to the selection of formulas and the arrangement of computations. Problems showing applications as well as drill problems are given. Extensive use is made of measurements in mils. The book devotes some thirty-six pages to spherical trigonometry. These pages include the solution of right, isosceles, quadrantal, and oblique triangles. Applications to the terrestrial and celestial spheres are given. The tables include logarithms of numbers, logarithms of trigonometric functions using mils as well as degrees and minutes, natural functions using both degrees and mils, a table of squares, and a table for converting mils to degrees and degrees to mils.

Throughout the book computation rather than theory is stressed. The chapters on computation give a large number of drill problems as well as applications. The applications include navigation, gun fire, and surveying. Most of the applications are placed at the close of the chapters and may be omitted if a very rapid course is desired. Throughout the book explanations are well presented and terms are well defined. This text merits the attention of teachers of trigonometry especially those giving courses stressing computation.

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SOLID GEOMETRY, by A. M. Welchons and W. R. Keickenberger, both of the *Mathematics Department of the Arsenal Technical High School of Indianapolis, Indiana.* Revised edition 1943. Pages viii+276. Ginn and Company. Price $1.48.

This new solid geometry textbook is an edition revised to conform to recommendations made by mathematics teachers who have used the old edition. The solid geometry material is well covered; and, unlike many textbooks of this type, contains an abundance of problem materials. The introduction is especially good with its fine review of plane geometry, its simple introduction to solids, and the clear transition from plane to solid geometry. The important propositions are starred, and the problems are placed in groups A, B, and C according to their difficulty. The book concludes with many supplementary topics, miscellaneous exercises, and an excellent set of tables.

This edition possesses several fine characteristics. It is written in a simple, clear, and definite style making it possible for the student to do some of the work on his own initiative. There is such an abundance of theory and problems that the text can be adapted to any class thus making allowances for individual differences. Theory well presented, sufficient material, and attractive make-up determine a good mathematics textbook. In my estimation this book has these three qualifications.

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GENERAL CHEMISTRY, (Fifth Edition) by Horace G. Deming, *Professor of Chemistry, University of Nebraska,* Cloth. Pages x+712. 15×21.3 cm. 1944. John Wiley and Sons, 440 Fourth Avenue, New York 16, New York. Price $3.75.

This latest addition to the well-known series of textbooks by the same author measures up to the high standards which he has maintained. The first four editions of the General Chemistry appeared at five year intervals. The Fifth Edition follows the Fourth at an interval of nine years.

In the preface to the present book, the author announces that "the treatment of the fundamental principles has been simplified and curtailed to gain space for a discussion of industrial applications." Even a casual examination of the book convinces the reader that this policy has been carried out at all points. The author has been unusually successful in condensing to small space, explanations and discussions which commonly require many pages. As illustrations, it may be noted that the Second Edition devoted 10 pages to the subjects of valence and formulas, while the Fifth Edition uses about 4 pages for an explanation of these items. In the Second Edition the metals occupied 175 pages, in the Fifth Edition, 115. It will doubtless be necessary for a teacher to give much supplementary explanation because many students will find the new book pretty highly concentrated intellectual food.

The choice of subject matter has been carefully made and the development is as complete as could be expected in limited space. Some of the topics of current interest which are included are: dehydration of foods, the atmosphere at high elevations, water softening and conditioning, wetting agents and detergents, explosives, plastics, synthetic elastomers, light metals, corrosion and many other topics of great interest in war time and reconstruction periods.

The mechanical features of the book are excellent in spite of the fact that the effect of war time conditions are in evidence in the narrow margins and small type. The paper is light weight, but satisfactory. The illustrations are largely in the line drawing style and all have a distinct educational value. At the close of the chapters there are thought-provoking exercises and references to readily accessible sources of additional information. Explanatory footnotes are numerous. The appendix contains nine pages of useful tables. The index is complete and in useful form. Following the index are to be found a brief table of logarithms and hints on its use; a table of solubilities; and two forms of the Periodic Table. On the inside covers the author appeals to the student to regard this work as a book of reference as well as a textbook and to keep it in his own library in order that he may use it in future years "to refresh his memory of principles and facts and deepen and broaden his knowledge in the direction most likely to serve his work." Nearly all readers will agree that the author has written an excellent book which is logical and condensed as a textbook and abundantly worthy of preservation as a book of reference in applied chemistry.

B. S. HOPKINS

THE SCIENCE OF EXPLOSIVES, by Martin Meyer, *Professor and Chairman of the Department of Chemistry, Brooklyn College*. Cloth. Pages xi+452. 14×21.5 cm. Nov. 1, 1943. T. Y. Crowell Company, 432 Fourth Street, New York, New York. Price $4.50.

This book is evidently an outgrowth of the author's course in Explosives which is given at Brooklyn College. The purpose of the author is to assemble in one book "in relatively simple and readable style," the present available information on the science of explosives. He "has attempted to emphasize a fundamental and practical viewpoint and to avoid the tendency to make it a textbook of synthetic organic chemistry." Very new developments are not treated at length because they are readily understood by one versed in the fundamentals; and "many of the current revolutionary

and secret discoveries—will later prove to be much less startling and important than their present buildup makes them appear." In order to make descriptions and procedures as accurate as possible the author has drawn freely from technical manuals and literature of the United States War Department and has received material of various kinds from the officers in the service, from several explosive manufacturers, instrument makers and technical publishers.

The book is evidently intended as a general reference work on explosives, as a laboratory guide for students who are studying explosives and as a book of information for those who are aiming to qualify as chemists or inspectors. The book does a good job of teaching the chemistry of explosive as is evident by the number of experiments which are included, the frequent chemical reactions, the tables in the appendix and the tables of atomic weights on both front and back covers.

The general reader who is seeking information upon the subject of explosives will find the chapters logical in arrangement, clear and simple in presentation and not too technical in language. Some attention is given to the physics and physical chemistry of explosives. This will probably be sufficiently technical for practical purposes and if it becomes somewhat involved, it may easily be omitted by the non-technical reader.

The general scope of the book may be ascertained from the chapter headings. Some of these cover The Nature of Explosives, Black Gunpowder, Nitrocellulose, Nitroglycerine, Theory of Explosive Action, Grain Size and Shape, Smokeless Powder, T.N.T., Initiators, Explosive Devices, Igniting Devices, Inspection and Analysis, Application and Use, Packing, Shippping, Storage, and Safety. Supplementing these chapters on the direct study of explosives are sections on the sulfuric acid, nitric acid, nitrogen fixation and ammonium nitrate. Most general readers will be particularly interested in reading the sections on the causes of accidents in the manufacture and use of explosives and the practical suggestions for their prevention.

The author is to be congratulated for his success in providing an interesting and valuable book, which admirably meets the needs of those who wish to be informed about current practices with explosives as well as those who wish to receive training in this field at a time when explosives of various types are being used in such huge quantities for such a wide variety of purposes.

B. S. HOPKINS

BIOLOGY FOR HIGH SCHOOLS, by Sister M. Dafrose, O.P., *Chairman, Science Department, Bishop McDonnell High School, Brooklyn, New Tork.* Cloth. 15×21.5 cm. Pages xvii+796. 470 reproduced photos, 75 diagrams, 15 tables, 11 drawings and 1 map.

This text is divided into six sections under these titles: I—Human Environment. II—Resemblances. III—Animals. IV—Man. V—Plants. VI—Science Marches On. The sections are divided into 36 chapters. Each chapter ends with a good summary, a quiz, suggested activities (laboratory exercises), suggested biographies to read and suggested library research investigations. An appendix has the following items: a good list of films, a reading list and a biographical index of the scientists mentioned and quoted in the text. The book ends with a good glossary and subject index.

An interesting feature of this book is the well thoughtout use of tables. These tables do not appear to be put in to fill space, they are understandable by the student. Plainly labelled and referring to the text material. So often tables and illustrative material appears in textbooks which have little meaning because of poor labelling and legends which have little rela-

tion to the text material. Another item of interest is an unusually well selected large number of pictures of the men and women who have built up the science of biology. This biology text is one of the few if not the only one which in its context refers to and makes plain a philosophy which underlies the origin of life. In fact one of the objectives stated by this text for the teaching of biology is the attempt to convey the realization that there is a Supreme Being. An Intelligence which plans and guides the evolvement of living things.

A. G. ZANDER

MANUAL OF WARTIME HYGIENE. Supplement to "A College Textbook of Hygiene" by Dean Franklin Smiley, A.B., M.D. *Professor of Hygiene and Preventive Medicine in Cornell University, Lt. Commander, United States Naval Reserve* and Adrian Gordon Gould, Ph.B., M.D. *Attending Physician and Assistant Professor of Hygiene and Preventive Medicine in Cornell University. Lt. Colonel Medical Corps, United States Army.* Paper. 14×21 cm. Pages iii+86. 5 drawings, 3 reproduced photos, 1 table, 1 map and 3 diagrams.

This little book is designed to give the college student the fundamentals of the practice of hygiene from the standpoint of war time needs. Most college students are subject to military service hence certain training must be reoriented to this end. This booklet aims to do this. Many college men are trained for commissions in the armed forces, their background in hygiene must meet this new situation. Hygiene to the officer must mean not only a more efficient personal hygiene but a hygiene organized and capable of being carried out efficiently for a large group simultaneously. The booklet is divided into three parts: 1—Military hygiene; 2—Civilian defense; 3—War time first aid. A bibliography, short appendix and index complete the book.

A. G. ZANDER

PLANE AND SPHERICAL TRIGONOMETRY, by Alfred L. Nelson, *Professor of Mathematics, Wayne University,* and Karl W. Folley, *Associate Professor of Mathematics, Wayne University.* Cloth. Pages xiv+247+135. 1943. Harper and Brothers Publishers, New York. $2.40.

This text is a revision of a 1936 edition by the same authors. Current demands have led them to make substantial changes in the book. Foremost among these are using the acute angle approach in defining the trigonometric functions and altering the order of the topics so that the great bulk of numerical trigonometry is completed in the first five chapters. Another interesting feature is the inclusion of a section on the solution of oblique triangles before logarithms are presented. The logarithmic solutions of the oblique triangle are then given later. The most abstract topics in the course, identities, inverse functions, and equations, are placed at the end of the course in plane trigonometry.

The problem material and the illustrations reflect the recognition of the demands of the armed forces and industry. A discussion of the mil as an angular unit together with problems involving it are given in Chapter I. The idea of vectors is explained and used in connection with problems from mechanics and the more elementary applications to aeronautics. The authors state that most of the problems in this second edition are new ones.

In spherical trigonometry, in addition to the usual content, the authors have a chapter on applications, principally to navigation. For use here they give tables including the values and logarithms of haversines and a

list of latitudes, longitudes, and meridional parts of a number of positions on the earth.

Among other features five place tables are included in the back of the book. The drawings and illustrations are clear cut and well made. The explanations are concise, yet complete. Adequate use is made of illustrative examples. The book is very rich in exercise and problem material, far too much to use with a single class. The book deserves careful examination by teachers looking for a new text in trigonometry.

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Mathematics for Machinists, by R. W. Burnham, *Principal, Haaren High School, New York City*. Second Edition. Cloth. Pages xii+253. 12×17.5 cm. 1943. John Wiley & Sons Inc., New York, N. Y. Price $1.50.

In writing this book the author had in mind the purpose of presenting machine shop calculations in a simple way with just enough explanation of the principles of the machine concerned to make it possible for the machinist to understand them. The book is designed to help the beginning machinist of today to a more thorough understanding of his daily work even though he receives little instruction on the job.

The fundamental principles of mathematics are presented under such topics as: common fractions, decimal fractions, percentage, simple geometric constructions, formulas, powers and roots, ratio and proportion, surface and volume measurements, the rule of Pythagoras, and shop trigonometry.

Among the topics dealing with specific trade training are included the following: blueprints, direct instrument measurement, lathe work, thread cutting, planer, shaper and drill press, simple machines, gear calculations, milling machine indexing, and materials and processes.

Throughout the text all explanations are clear and concise and are accompanied by excellent illustrations and diagrams. An abundance of problem material enables the student to gain a working knowledge of the topics discussed. Many of the problems presented are those actually encountered every day in the shop. With the help of the answers found at the end of the book the average trainee should find it possible to make satisfactory progress even without the aid of an instructor. Each chapter is concluded with a rather extensive list of practical review exercises.

The appendix includes a number of useful tables in addition to some thirty formulas commonly used in the machinist trade.

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Calculus, by Lyman M. Kells, *Professor of Mathematics, United States Naval Academy*. Cloth. Pages viii+509. 16×23.5 cm. Prentice-Hall, Inc., 70 Fifth Avenue, New York, N. Y. Price $3.75.

Professor Kells has written several very teachable texts. This one follows the direct, simple approach of the preceding texts. Full use of review as an aid to learning is a special feature of the text. The pictures are excellent. The level of rigor is above the average.

Every teacher of Calculus should have this text on his shelf and should examine it for the clear and logical presentation of the subject matter.

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